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User's Guide to CHEAPO II—Economic Analysis of Stand Prognosis Model Outputs

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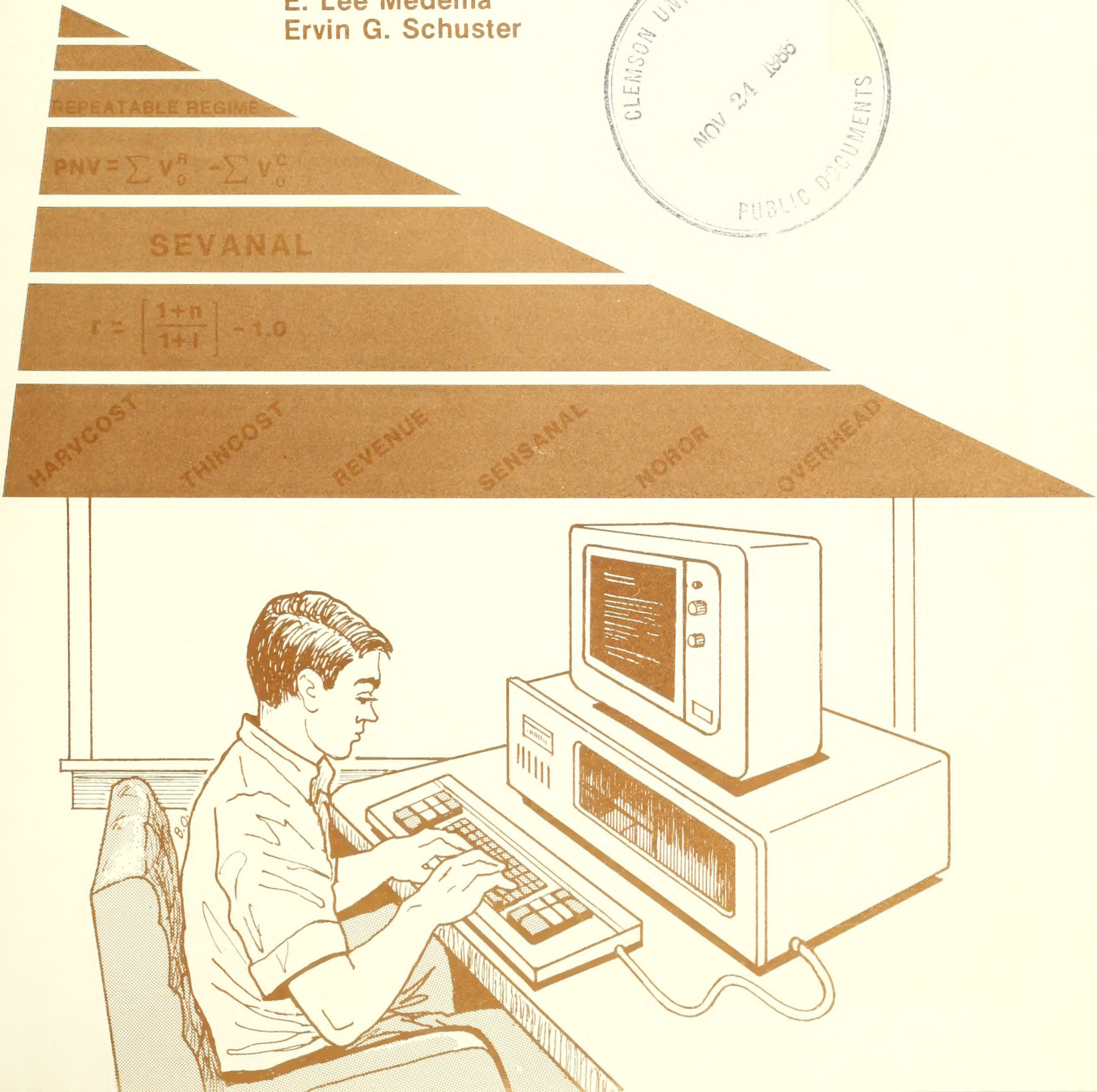

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RESEARCH SUMMARY

Since its introduction in 1979, CHEAPO, a computer-based economic analysis program, has allowed users of the Stand Prognosis Model to evaluate silvicultural alternatives from an economic point of view. Subsequent modifications to the Prognosis Model have rendered CHEAPO obsolete. This user's guide covers a new computer model, CHEAPO II, which is compatible with version 5.1 of the Prognosis Model and expands its economic analysis capabilities.

CHEAPO II allows users of the Prognosis Model to analyze the economic aspects of management treatments projected by the latest version of the Prognosis Model and its associated extensions: the Regeneration Establishment Model and the Douglas-fir Tussock Moth Outbreak Model. CHEAPO II has been designed to allow users flexibility in the types of stands that can be analyzed (existing or regenerated), the types of management regimes analyzed (even- or uneven-aged), the types of economic analyses undertaken (present net value, soil expectation value, and present net value plus), and the economic decision criteria that can be used (present net value, benefit-cost ratio, and rate of return). CHEAPO II represents a powerful analytical tool for analyzing proposed investments in stand management alternatives.

From a user's standpoint, CHEAPO II functions very much like the old CHEAPO and its input format was patterned after the Prognosis Model. CHEAPO II uses information from two data files—one generated by the Prognosis Model and the other provided by the user. The user-created data file amounts to a set of instructions to CHEAPO II through keyword records. These keyword records instruct CHEAPO II as to: (1) which of the three types of economic analyses is to be performed; (2) the costs and revenues associated with a variety of silvicultural treatments; and (3) how output and reports are to be presented. CHEAPO II execution ends with printing of tabular output displaying the set of instructions given CHEAPO II, economic analysis results, a listing of the undiscounted cash-flow, and optional stand tables. This user's guide describes the CHEAPO II model, the model's input data requirements, and the model's tabular output.

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INTRODUCTION

Forest managers utilizing the timber Stand Prognosis Model (Stage 1973; Wykoff and others 1982) to project and evaluate silvicultural alternatives have found the computer model CHEAPO (Computerized Help for the Economic Analysis of Prognosis Model Outputs) (Medema and Hatch 1982) to be a useful tool for analyzing the economic implications of alternatives. CHEAPO users include public (State and Federal) and private (forest industry and nonindustrial) forest managers. Although CHEAPO could be used with any computerized timber yield projection system, its application has been limited to the Prognosis Model, the system with which it was designed to interface.

Since CHEAPO's introduction in 1979, the Prognosis Model has been modified and several analytical extensions have been added, including the ability to model stand regeneration (Ferguson and Crookston 1984) and potential outbreaks of the Douglas-fir tussock moth (Monserud and Crookston 1982). These Prognosis Model extensions have rendered the original version of CHEAPO obsolete. Yet the need to assess economic implications of management options still remains.

This user's guide describes a new economic analysis model called CHEAPO II. The model enables users to undertake economic analyses utilizing the current version (version 5.1) of the Prognosis Model and its associated extensions. CHEAPO II is more than a simple update required by modifications to the Prognosis Model. New features and analytical capabilities have been added, including cost and revenue assignment by tree diameter size class, analysis of uneven-aged management regimes, and output of stand table information. Development of CHEAPO II was coordinated with extensions to the Prognosis Model. Additionally, the user-specified data requirements for CHEAPO II are comparable to those of the original CHEAPO. The user already familiar with CHEAPO should have little difficulty adapting to CHEAPO II.

This user's guide is intended to be easily understood and of practical use to general forest managers. Throughout this manual, however, a certain level of prior knowledge is assumed. First, **it is assumed that the user is familiar with the Prognosis Model**. CHEAPO II was specifically designed to interface with version 5.1 of the Prognosis Model, the Regeneration Establishment Model, and the Douglas-fir Tussock Moth Outbreak Model. Separate user's guides are available for the Prognosis Model (Wykoff and others 1982) and the above extensions (Ferguson and Crookston 1984; Monserud and Crookston 1982). Like CHEAPO, the CHEAPO II model is merely an optional program that may be used in conjunction with the Prognosis Model. This manual is intended to familiarize users only with CHEAPO II, not the Prognosis Model.

Second, **it is assumed that the user is familiar with the basic economic techniques of timber stand investment analysis.** This manual is not intended to be a primer in economic analysis. CHEAPO II can be a powerful economic analysis tool because the program allows for a great deal of flexibility in specifying economic assumptions underlying the stand analysis. It is possible, however, to incorrectly formulate an economic analysis and yet generate output (albeit incorrect) from the model. It is also possible to formulate a correct analysis and incorrectly interpret the model output. Therefore, a basic understanding of timber stand investment analysis is a prerequisite to the effective use of both this manual and the program itself. Users not familiar with how economic assumptions such as discount rates, timber as capital, and infinite rotation vs. single rotation analyses influence investment decisions and management practices should review these concepts before using CHEAPO II. This information can be found in forest finance, economics, or management texts, including Davis (1966), Duerr (1960), Gregory (1972), Leuschner (1984), and Clutter and others (1983).

The purpose of this user's guide is threefold:

-Describe and explain the economic analysis capabilities of CHEAPO II.

-Describe and explain the input data needed to run CHEAPO II.

-Describe and explain the output (or results) of CHEAPO II.

With these purposes in mind, the next section provides the user with a brief overview of CHEAPO II and its linkage to the Prognosis Model. Subsequent sections describe data input and examples, along with program output examples.

MODEL OVERVIEW

CHEAPO II processes relevant timber yield projections and economic information on forest management alternatives. Timber yield information is provided to CHEAPO II by the Prognosis Model. Economic information is provided by the user. All information is transformed into a comprehensive economic efficiency analysis for a specified planning horizon based on the type of economic analysis specified by the user. The economic analysis results are expressed in terms of traditional investment decision criteria, including present net value (PNV), benefit-cost ratio (B/C Ratio), rate of return (ROR), and more depending on the analysis specified. These can be used to assess the economic desirability and rank the economic attractiveness of alternative management programs.

Investment Decision Criteria

Investment decision criteria are alternative indexes used to assess the finanacial desirability of individual investments and to compare the relative desirabilities of alternative investments.

CHEAPO II uses three basic criteria—present net value is expressed in dollars; benefit-cost ratio is expressed as a unitless number; rate of return is expressed as a percentage. Present net value is the present (or discounted) value of benefits minus the present value of costs. PNV is also known as present net worth. The benefit-cost ratio is the present value of benefits divided by the present value of costs. Rate of return is the discount rate that makes the present value of the benefits equal to the present value of the costs, that is, where the present net value equals zero. ROR is the average annual net compound growth rate over the investment's life, also known as the internal rate of return and the return on investment. Identified by an iterative search procedure within CHEAPO II, the ROR is independent of any user-specified discount rate.

The investment criterion used should depend on the purpose of the analysis and may also depend on management or organizational policy. For example, present net value is the preferred criterion for use in the USDA Forest Service. An individual investment is economically desirable if (1) the present net value is greater than 0.0, (2) the benefit-cost ratio is greater than 1.0, or (3) the rate of return is greater than some minimum acceptable (or guiding) rate of return on investment.

In analyzing a single investment alternative, the decision criteria provide consistent results. That is, the present net value, benefit-cost ratio, and rate of return criteria will all consistently portray a given alternative as being either economically desirable or undesirable. In comparing two or more "mutually exclusive" investment alternatives, however, the three decision criteria may yield conflicting results. For example, present net value and benefit-cost ratio may indicate that one alternative is preferred but rate of return may indicate another. Alternative investments are said to be mutually exclusive if investment in one precludes investment in the other. For example, the decision to undertake one management treatment on a particular stand precludes undertaking an alternative treatment. Either treatment may be adopted, but not both. The reason for the potential inconsistency of the decision criteria regarding the comparison of mutually exclusive investment alternatives results from differences in how each criterion handles (1) differences in the size of the investments, (2) differences in investment time horizons, and (3) assumptions regarding what is done with intermediate revenues generated during the investment time horizons. For further explanation, refer to Wippern (1974), Mishan (1971), or Mills and Dixon (1982).

Data and Analyses

CHEAPO II input is in two forms. The first is a special data file made available to CHEAPO II by the Prognosis Model. Projected stand statistics, removals, and a list of the management treatments specified in the Prognosis Model become the data elements comprising this CHEAPO II input file. The second input file contains economic information and related assumptions supplied by the user. The user must also instruct CHEAPO II as to the type of economic analysis desired. Analyses can pertain to management regimes on either existing forest stands or on essentially bare land—recently clearcut land intended for regeneration. The user specifies one of three types of economic analysis for CHEAPO II to perform: (1) present net value analysis (PNVANAL), (2) soil expectation value analysis (SEVANAL), or (3) present net value plus analysis (PNVPLUS). Analyses, implications, and results associated with each type of analysis are different (table 1).

Table 1.—Economic analysis information displayed for three types of economic analyses

	Economic analysis information displayed					
	Finite time horizon[1]				Infinite time horizon	
	Present value benefits and costs	Investment criteria				
Type of analysis		PNV	B/C ratio	ROR	SEV	PNVPLUS
PNVANAL	yes	yes	yes	yes	no	no
SEVANAL	yes	yes	yes	yes	yes[1]	no
PNVPLUS	yes	yes	yes	yes	no	yes[2]

[1]Information provided for each cycle.
[2]Information provided for repeatable management regime portion.

Present Net Value Analysis.—PNVANAL computes the value of the discounted benefits and discounted costs for each cycle of a management regime projected by the Prognosis Model. Present net value analysis is the least complicated form of analysis available in CHEAPO II. PNVANAL is designed to discount the benefits and costs associated with a projected management regime and to calculate a present net value, benefit-cost ratio, and rate of return for each cycle of the regime. The time horizon of this investment analysis technique is finite, dictated by the length and number of cycles specified in the Prognosis Model projection. Hence, PNVANAL ignores any future growth of the existing timber crops or of additional timber crops beyond that time horizon.

Given the time limitations above, PNVANAL can be applied to an analysis of either existing stands (fig. 1) or clearcut stands intended for regeneration (fig. 2). PNVANAL is useful not only for comparing the economic efficiency of alternatives, but also for determining the economically optimal harvest age of the stand for one rotation. The harvest age can be defined by any one of the investment decision criteria: PNV, B/C Ratio, or ROR. Because each of these decision criteria are calculated and displayed for the end of each cycle and the beginning inventory year, the user can easily identify the year at which the selected criterion has the largest value.

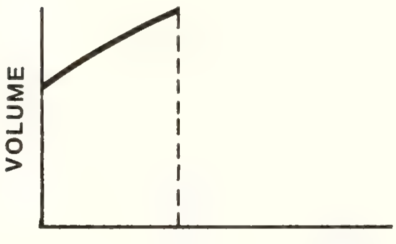

Figure 1.—Finite investment horizon for an existing stand.

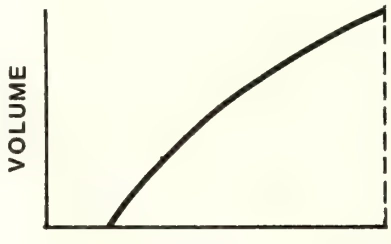

Figure 2.—Finite investment horizon for a regenerated stand.

Soil Expectation Value Analysis.—SEVANAL evaluates management options over an infinite time horizon. Soil expectation value (SEV) is also known as land expectation value. In CHEAPO II, the **soil expectation value analysis is applicable only to recently clearcut areas intended for regeneration that are to be managed on an even-aged management basis**. The stand regeneration extension (Ferguson and Crookston 1984) feature of the Prognosis Model allows the user to project stand establishment; the soil expectation value feature in CHEAPO II is tailored for this type of Prognosis Model projection. A typical purpose of using the soil expectation value analysis is to determine an optimum rotation age that recognizes all future rotations. Another use of SEVANAL is to compare management regimes over an infinite time horizon.

SEVANAL is basically a present net value model that seeks to identify the largest present net value of land devoted to timber production in perpetuity. As with any productive asset, the value of land (bare land) devoted exclusively to timber production is derived from the value of the products it produces (crops of trees). Therefore, rather than determining the present net value over a finite investment horizon, SEVANAL determines the present net value of an infinite series of identical timber crops (fig 3). This specific present net value is soil expectation value. The soil expectation value can be thought of as the present net value decision criteria applied to an infinite time horizon.

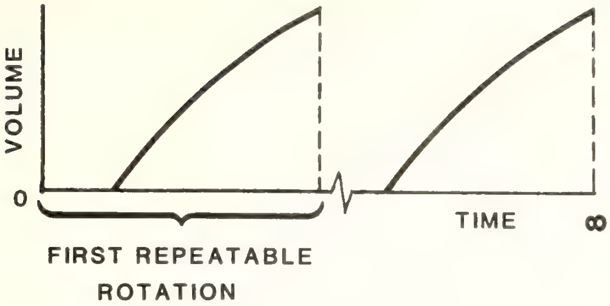

Figure 3.—Infinite investment horizon for a regenerated stand.

Given a specified management regime, CHEAPO II calculates the soil expectation value at the end of each cycle. Hence, the management regime that starts at the beginning of the Prognosis Model projection and ends with each cycle is treated as an infinitely repeatable management regime. By varying the management treatments on subsequent Prognosis Model projections, the user can identify the management regime and rotation age that produces the greatest soil expectation value among the alternatives analyzed. The soil expectation value analysis also gives the PNV, B/C Ratio, and ROR associated with a finite time horizon that concludes at the end of each Prognosis Model cycle.

Present Net Value Plus Analysis.—PNVPLUS was included in CHEAPO II to allow users to **analyze investments using uneven- or even-aged management regimes that start with existing forest stands** and that cover an infinite time horizon. This analysis became appropriate when the Regeneration Establishment Model (Ferguson and Crookston 1984) was incorporated into the Prognosis Model. The Regeneration Establishment Model added flexibility in the type of management regimes that can be projected, especially in uneven-aged management situations. But, such flexibility increases the complexity in the analytical procedures of an economic analysis.

Starting with an existing stand, the user may want to analyze the discounted benefits and costs only over the finite time horizon specified in the Prognosis Model projection. If this is the case, PNVANAL should be used. The user, alternatively may decide to undertake an economic analysis of a management strategy that begins with an existing stand, goes through a transition period, and continues with a management regime that is repeatable over an infinite time horizon. In this case, PNVPLUS should be used. When the condition of a repeatable management regime has been achieved (as specified by the user), it is presumed to continue ad infinitum, and the resulting PNVPLUS calculations include these yields along with their associated benefits and costs. The repeatable management regime may encompass uneven-aged management (fig. 4) or even-aged management treatments (fig. 5).

It is important to note that the repeatable management regime should be justifiable on strong biological grounds. PNVPLUS within CHEAPO II can repeat **any** management regime ad infinitum, regardless of its biological feasibility. Therefore, only those repeatable regimes that are biologically realistic should be analyzed by the PNVPLUS option of CHEAPO II.

The PNVPLUS analysis is a composite of PNVANAL and SEVANAL. During the transition period (figs. 4 and 5) the analysis is handled as in PNVANAL. Costs and revenues are simply discounted to investment year zero. The repeatable management regime portion of the problem is handled like a SEVANAL in that the present net value is calculated as an infinite series of

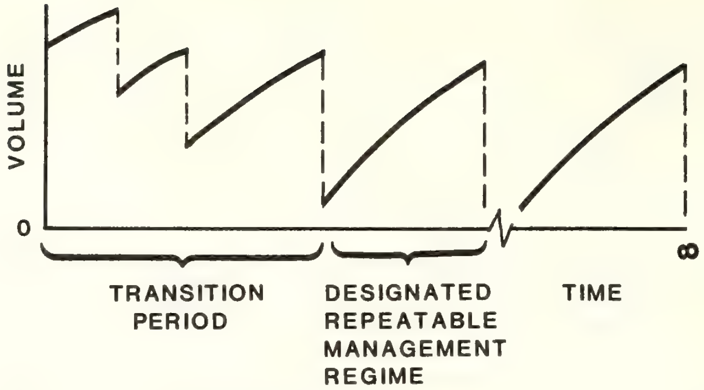

Figure 4.—Infinite investment horizon for an existing stand with an uneven-aged management regime.

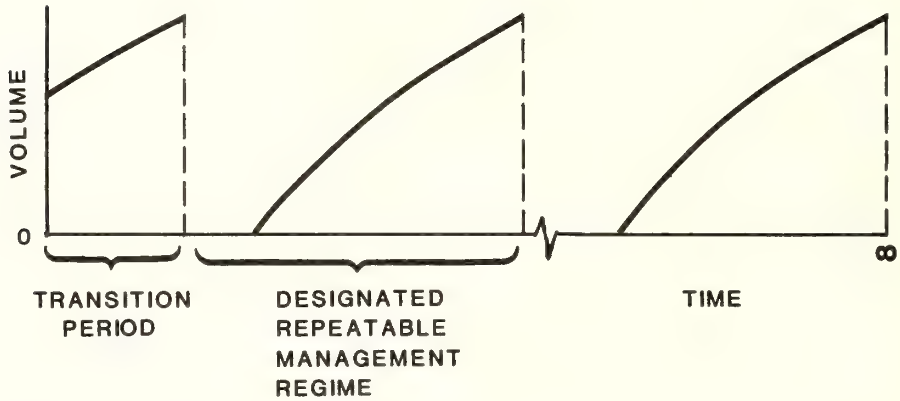

Figure 5.—Infinite investment horizon for an existing stand with an even-aged management regime.

identical rotations. Similar to SEVANAL, PNVPLUS also provides PNV, B/C Ratio, and ROR measures associated with a finite investment time horizon concluding at the end of each cycle. Also, like SEVANAL, the present value of the PNVPLUS results is an extension of the PNV selection criteria to an infinite investment horizon.

Prognosis Model-CHEAPO II Interface

Discussion of the Prognosis Model-CHEAPO II interface covers three topics: (1) model linkages, (2) the timing of future stand projection and economic analysis events, and (3) multiple stand analyses. It is important to understand these topics and the associated nomenclature, analytical options, and analytical limitations of the model interface.

Model Linkage.—Unlike Prognosis Model extensions, CHEAPO II does not interact dynamically with the Prognosis Model. The Prognosis Model, however, can be instructed to generate and "store" a special output file of stand projection information. This stored file will be retrieved and used as an input by CHEAPO II. Because this file is stored external to the Prognosis Model, it is possible to either execute CHEAPO II and the Prognosis Model in the same run or to "save" the special file generated by the Prognosis Model and run CHEAPO II at a later time.

The actual procedures used to store, retrieve, and save this special file are dependent on the job control language of the specific computer system used. Because the actual procedures vary from installation to installation, they are not discussed here.

Timing of Events.—The time perspective of a CHEAPO II economic analysis is a present-day analysis of the costs and revenues associated with silvicultural treatments planned for the future. Although treatment costs may provide valuable information and insights into an actual or hypothetical analysis starting with bare land, past expenses are "sunk" costs for an existing stand and, hence, irrelevant to decisions about its future. **The relevant investment time perspective starts today (investment year zero)** and continues into the future. Therefore, the timing of future events projected by the Prognosis Model is critical to the discounting calculations in CHEAPO II. All calculations for the investment decision criteria in CHEAPO II are based on the values of costs and revenues discounted to the present (investment year zero).

The time element in the Prognosis Model is initiated by a user-specified **inventory year**. The user also controls the length of the Prognosis Model projection by specifying the number and length of growth **cycles** to be projected. The Prognosis Model, given initial stand conditions and starting with the inventory year specified, projects stand development and displays stand output information at the end of each growth projection cycle.

For example, assume the actual (today's) date and inventory year are 1985 and stand information is desired to be displayed every fifth year (a cycle length of five) for four cycles. Each cycle in the Prognosis Model projection would encompass a 5-year period and would extend for 20 years, as shown in figure 6. Stand information would be displayed and dated 1985 for the initial stand conditions, and 1990, 1995, 2000, and 2005 for the projected stand conditions. Stand information and dates are part of the special file created for CHEAPO II by the Prognosis Model. Similarly, silvicultural treatments that were specified using the Prognosis Model and their corresponding date of occurrence are part of that special file. Therefore, the user need not be concerned with the actual transfer of information, but should be aware of the interpretation of dates by CHEAPO II.

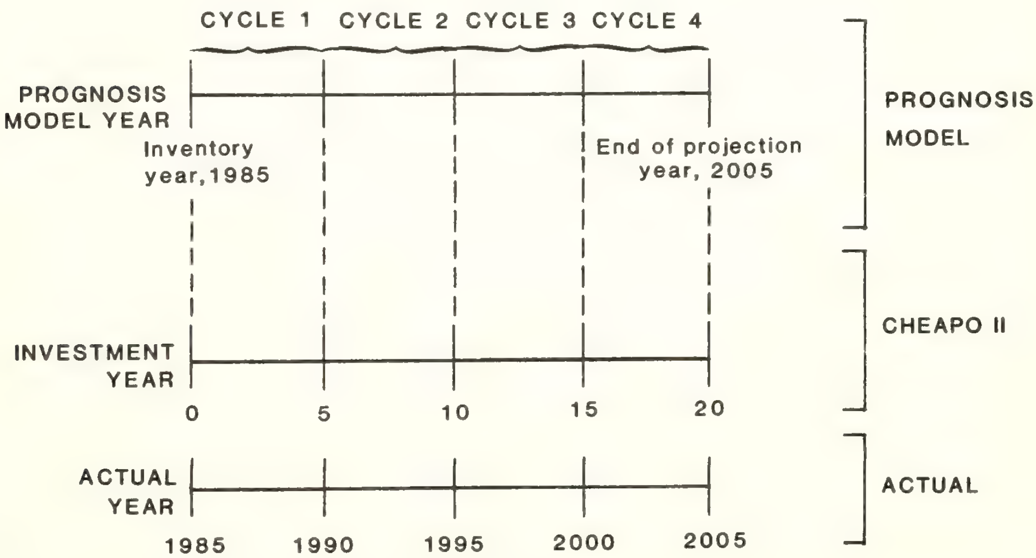

Figure 6.—Prognosis Model—CHEAPO II time interface.

Consider the easiest case first, that of analyzing an existing stand for a finite time horizon using PNVANAL. The inventory year (1985 in the fig. 6 example) is interpreted by CHEAPO II to be the beginning year (investment year zero) of the investment analysis time horizon. Any costs or revenues occurring in this year would reflect present (today's) values and would not need to be discounted. But any projected cost or revenues after this inventory date would be discounted by CHEAPO II. For example, if costs and revenues were projected to occur at the beginning of the second cycle, they would be discounted to the present by CHEAPO II for 5 years. CHEAPO II is not as much concerned with the actual date (such as 1990) specified as with the length of time (number of years) that elapses between the occurrence of cost and revenue producing treatments and the initial inventory year specified in the Prognosis Model projection (investment year zero). In PNVANAL, the length of the Prognosis Model projection determines the length of the investment time horizon.

In the SEVANAL and PNVPLUS analysis types, however, an infinite time horizon is used for CHEAPO II calculations. This is accomplished by treating the Prognosis Model projection, or a portion of the projection, as an infinite series of repeatable management regimes. SEVANAL is assumed to start with bare land in investment year zero (fig. 6) and treats the Prognosis Model projection to the end of the first cycle as a repeatable management regime. CHEAPO II also treats the projection to the end of the second cycle as a repeatable management regime, and so on until the end of the last cycle. Therefore, using the example in figure 6, a soil expectation value would be calculated for a perpetual series of rotation ages of 5 years (1985-90), 10 years (1985-95), 15 years (1985-2000), and 20 years (1985-2005). PNVPLUS starts with an existing stand at investment year zero and treats the portion of the Prognosis Model projection occurring after the user-specified transition period as an infinitely repeatable management regime.

An additional difference can occur between the Prognosis Model projection time horizon and the CHEAPO II investment time horizon. In CHEAPO II, the user has the option of analyzing an existing stand as if the analysis started from bare land. This is accomplished by "tricking" CHEAPO II regarding the occurrence dates for events (fig. 7) in the Prognosis Model projection. For example, assume the actual date and the stand inventory year for an existing

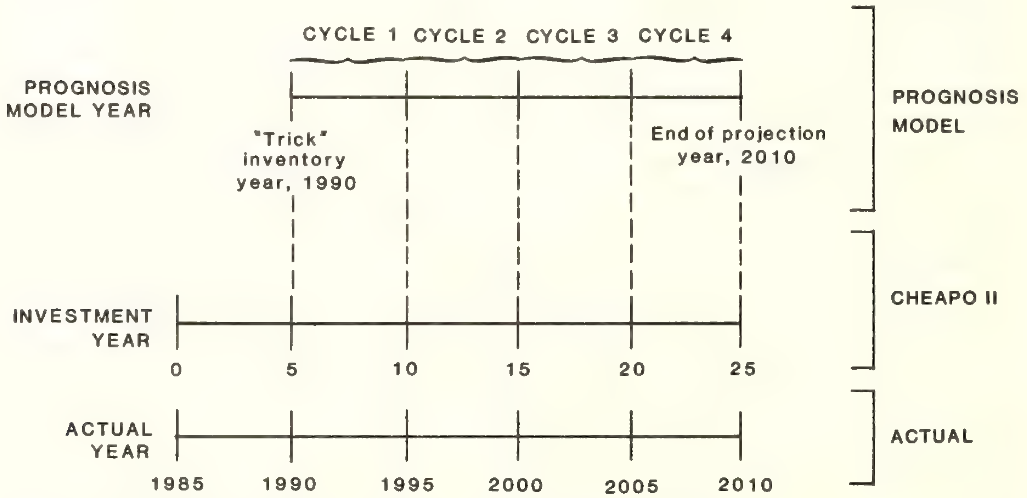

Figure 7.—Prognosis Model—CHEAPO II time interface adjustment to undertake a soil expectation value analysis on an existing stand.

stand are 1985 and the inventoried stand is the result of previous activities—site preparation and planting 4 years ago on a site that was clearcut 5 years ago (hence bare land). The user could "trick" CHEAPO II into conducting an analysis that effectively starts from bare land by (1) entering the inventory year as 1990 in the Prognosis Model projection; (2) dating the planting and site preparation costs to occur in 1986; and (3) specifying 1985 as the year of stand establishment, beginning of the investment time horizon.

Multiple Analyses.—Multiple analyses are possible with the Prognosis Model and CHEAPO II. In explaining this phase of the interface, it is necessary to review some terms. A **stand** is the initial set of tree records used in a Prognosis Model projection. The initial **tree records** are either entered by the user or are generated by the Prognosis Model. A **stand projection** is the growth and yield information generated by the Prognosis Model for a stand based on management treatments specified by the user. The Prognosis Model is capable of projecting as little as a single stand with a single management regime or multiple projections ("stacked projections") on a single computer run. Multiple (stacked) projections can include projections of: (1) several management regimes for a single stand, (2) a single management regime for each of several stands, or (3) several management regimes for several stands (fig. 8).

CHEAPO II has been designed to accommodate the above Prognosis Model flexibilities. CHEAPO II can undertake a single economic analysis for a single projection or a single economic analysis for each of the multiple (stacked) projections. Additionally, CHEAPO II has the capability to undertake multiple economic analyses for each projection, whether applied to a single projection or stacked projections (fig. 8). Instructions on how these analyses are actually accomplished are discussed in a later section.

DATA INPUT

This section pertains to the information that is entered in the user-specified CHEAPO II input file. When the Prognosis Model is executed, the user must specify (1) the existing stand conditions that are to be projected, (2) the length of the projection (including the number and duration of each cycle), and (3) the management treatments desired. The Prognosis Model then projects the stand over the specified period and generates a summary file for use by CHEAPO II. But the user must provide additional information instructing CHEAPO II how to conduct the economic analysis.

For each treatment specified in the Prognosis Model management regime, CHEAPO II requires additional information that includes identifying:

1. Stand treatments undertaken.
2. Unit of measure for each treatment.
3. Current (today's) costs or revenues for undertaking each treatment.
4. Current (today's) cost or revenue value rate changes (in either real or nominal terms).
5. Duration of each value rate change.
6. Discount rate (in either real or nominal terms, but same as 4 above).

The user must specify desired numerical values for economic variables. All variables are automatically set equal to zero (the default value incorporated into CHEAPO II) **and must be changed to be nonzero.** Tree volume units of measure in CHEAPO II differ from those used in the Prognosis Model. In CHEAPO

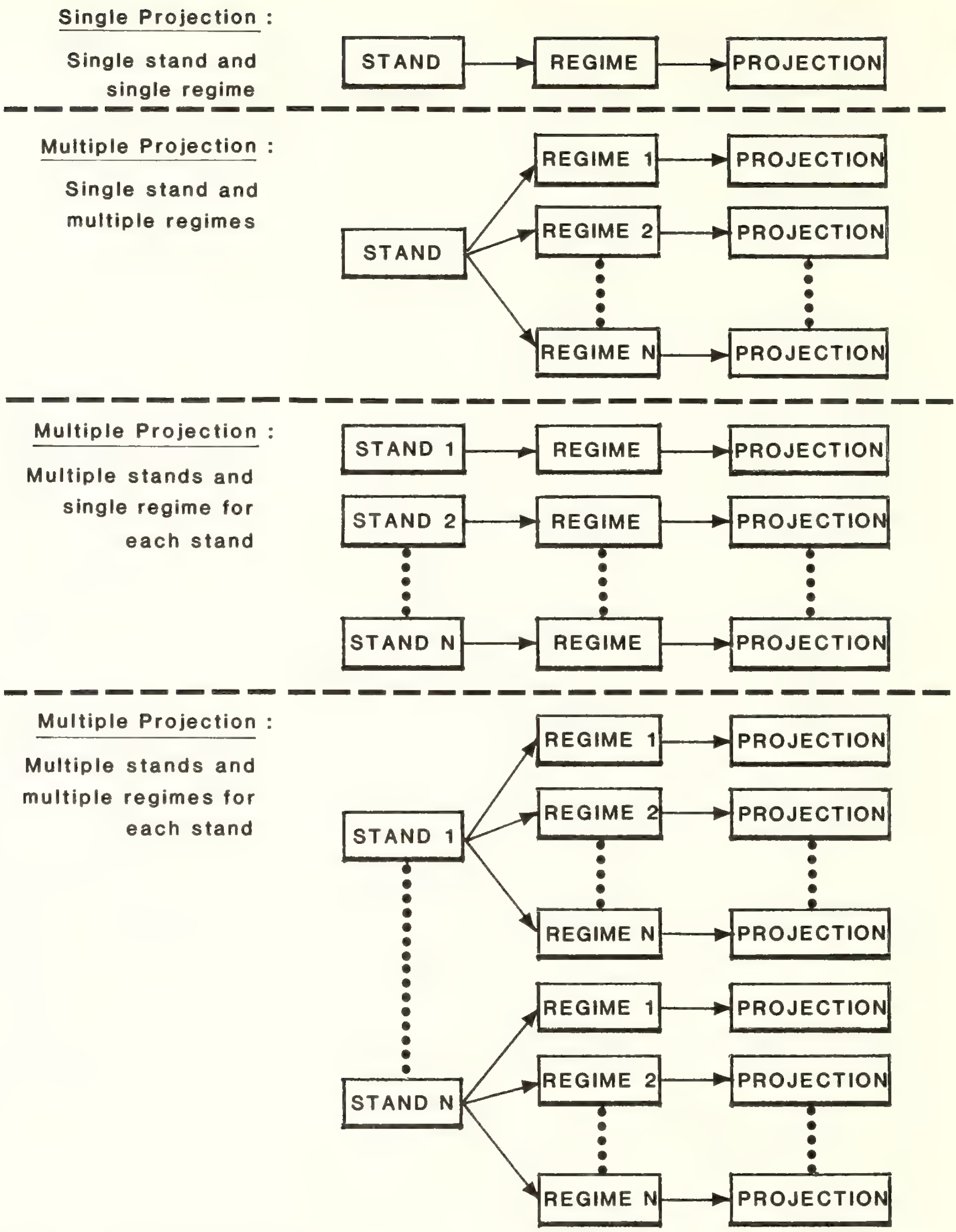

Figure 8.—Multiple projection options.

II, the board foot measure (BF) is recorded in units of **thousand board feet** and the cubic foot measure (CF) is recorded in units of **hundred cubic feet**; in Prognosis, both are recorded in units of one board foot or cubic foot.

Input Format

Users communicate all information used by CHEAPO II through a keyword system. The general keyword system is similar to that used by the original CHEAPO model and the Prognosis Model. Data and instructions are communicated to CHEAPO II in lines of formatted data called records. There are two types of records: keyword records and supplemental data records.

There are four types of formatted data fields: keyword, units/species, numeric, and continuation fields. The keyword field is eight columns long,

beginning in column 1 of the keyword record. The units/species field is a two-column field beginning in column 10. The units/species field is used to designate species or unit of analysis, as appropriate. Numeric fields 1-6 are used for entering economic analysis data and analysis control information, such as prices or costs, dates of occurrence, diameter size class specifications, value rate changes, and durations of value rate changes. **The continuation field is used to designate that additional data occur on a second, or supplemental record immediately following the keyword record**. This is accomplished by **entering the character C anywhere** in the 10-column field. The supplemental data record includes six additional numeric fields.

The column and field designations for both records are summarized as follows:

Record	Field	Columns	Column justification
Keyword	Keyword	1-8	Left-justified
	Units/Species	10-11	Left-justified
	Field 1	12-20	Right-justified if decimal points are not used. Anywhere within the field if decimal points are used.
	Field 2	21-30	
	Field 3	31-40	
	Field 4	41-50	
	Field 5	51-60	
	Field 6	61-70	
	Continuation	71-80	Anywhere in field.
Supplemental	Field 7	12-20	Right-justified if decimal points are not used. Anywhere within the field if decimal points are used.
	Field 8	21-30	
	Field 9	31-40	
	Field 10	41-50	
	Field 11	51-60	
	Field 12	61-70	

CHEAPO II keywords fall into four categories: analysis-type, economic assumptions, program execution, and output control. Each keyword will be introduced and its function defined in the course of describing how the model works. For reference, appendix A contains an index to pages on which keyword descriptions are given.

Analysis-type Keywords

There are three types of economic analyses available in CHEAPO II. The purpose of the analysis-type keyword is to indicate to CHEAPO II which type of economic analysis the user wants to perform. **Only one analysis-type may be specified for each individual economic analysis**. If more than one type is specified in the keyword file, the first one encountered is used. The following analysis-type keywords and their associated fields are available to CHEAPO II users:

PNVANAL Requests a present net value analysis. Cash-flows are discounted to the beginning of the stand projection based on user-specified assumptions concerning costs, revenues, and discount rate. PNV, B/C Ratio, and ROR measures are calculated for each cycle beginning with the inventory year specified on the Prognosis Model projection and ending with the year corresponding with the end of the last cycle projected. PNVANAL encompasses a finite investment time horizon. Investment year zero is the inventory year.

Units/Species: Unit of measure for volume assignment. BF=1,000 bd ft, CF=100 ft^3. . . . Default value is CF.

Fields 1-12: Blank.

SEVANAL Requests soil expectation value analysis. SEV is calculated at each cycle with the assumption that the management treatments projected through previous cycles are repeatable into the future to an infinite time horizon. PNV, B/C Ratio, and ROR measures are calculated at each cycle, to the end of the Prognosis projection, as if the corresponding investment age were the rotation length. SEVANAL is for all rotations and, hence, encompasses an infinite investment time horizon.

Units/Species: Unit of measure for volume assignment. BF=1,000 bd ft, CF=100 ft^3. . . . Default value is CF.

Field 1: Year of stand establishment (such as 1990). This is year zero for the investment time horizon and may precede the inventory year used in the Prognosis Model projection. . . . Default value is the inventory year specified in the Prognosis Model.

Fields 2-12: Blank.

PNVPLUS Requests present net value plus analysis. A transition period leading to the repeatable management regime is implicit in PNVPLUS. PNVPLUS, however, includes the value of all future repeatable management regimes and encompasses an infinite investment time horizon. PNV, B/C Ratio, and ROR measures are calculated for each cycle through the transition period and the first rotation of the repeatable management regime as if the corresponding investment age were the rotation length.

Units/Species: Unit of measure for volume assignment. BF=1,000 bd ft, CF=100 ft^3. . . . Default value is CF.

Field 1: Year designation corresponding to the date at which the repeatable management regime **begins**. . . . Default: if no year is specified, the entire analysis reverts to PNVANAL.

Field 2: Year designation corresponding to the date at which the repeatable management **ends**. . . . Default: if no year is specified, the entire analysis reverts to PNVANAL.

Fields 3-12: Blank.

Precautions have been built into CHEAPO II in an attempt to avoid a "double counting" of costs or revenues associated with the treatments that occur at the cycle boundary between the end of the transition period and the beginning of the repeatable management regime (figs. 4 and 5). Both occur at the same cycle boundary, a common date. The precaution is that **thinning and harvest costs along with associated harvest revenues are included as part of the transition period. All other activities are considered part of the repeatable management regime**. For example, if the year 2000 were designated as the beginning of

the repeatable management regime (it must be a cycle boundary) and a seed-tree harvest were scheduled on that date, then all revenues and costs associated with the removal operation would be included in the transition period. These costs and revenues would not be considered as part of the repeatable management regime; that is, they would not be repeated. But costs and revenues associated with all other treatments that occurred in the year 2000 would be included in the repeatable management regime. These distinctions are made on the basis of keywords.

Economic Assumption Keywords

The purpose of the economic assumption keywords is to enter the economic parameters (costs, revenues, discount rate, and so on) associated with the management treatments projected. Keywords to specify economic assumptions make up the majority of the keywords used in CHEAPO II. Economic assumption keywords provide information about (1) tree removal treatments, (2) cost items, (3) revenue items, and (4) the discount rate. Value rate changes and the duration of the value rate changes can be specified for all cost and revenue items. Costs can be assigned for thinnings, harvests, annual costs, special costs, and costs associated with management activities projected by the regeneration and Douglas-fir tussock moth outbreak extensions of the Prognosis Model. Revenues can be assigned for special revenues and for tree removals interpreted to occur at the beginning of the user-specified year. All **costs and revenues used should be entered as the actual values existing in the base year (investment year zero)** of the investment time horizon.

In computing the analytical results, CHEAPO II automatically interprets cost items to have negative values and revenue items to have positive values. Therefore, **signs (negative or positive) associated with these values are not to be routinely included**.

The costs and revenues entered should reflect any economies of scale that are present for the acreage size of the proposed investment. The Prognosis Model and, hence, CHEAPO II **conduct all analyses on a per-acre basis**. Whether the actual stand is more than or less than 1 acre, it is assumed that the acre analyzed reflects a representative composite of the stand and treatments proposed. Certain actual costs and revenues, however, may be subject to economies of scale. In site preparation, for example, the larger the area treated, the lower the per-acre costs. The user must take this into account when entering cost and revenue values.

Tree Removal Treatments.—Tree removal treatments are defined and specified by differentiating between a precommercial thinning operation (with a user-specified cost) and other thinning and harvest operations (with user-specified costs and revenues). The key analytical difference between these operations is that **a precommercial thinning operation is always a net cost, whereas other thinning and harvest operations may be a net cost or net revenue**, depending on the mix of costs and tree sizes, numbers, and values. The differentiation is accomplished by the user specifying **average tree size and volume standards** for removals.

Average tree size is expressed using the quadratic mean diameter of the trees removed. A quadratic mean diameter is defined as the diameter of the tree of average basal area. Quadratic mean is used rather than the simple, arithmetic mean because it is a more stable estimate of average tree size.

When a removal operation occurs and (1) the quadratic mean diameter of the trees removed is less than the user-specified diameter **and** (2) the total volume removed is less than the user-specified volume, CHEAPO II interprets the

removal as a precommercial thinning operation (a cost). If not, the removal is interpreted as another thinning or harvest operation, which may or may not be commercial.

These standards are entered with the keyword and field parameters as follows:

THINSPEC Average tree size and volume standards for defining tree removal treatments are entered. If the quadratic mean diameter of trees removed is less than the diameter specified, **and** the total volume removed is less than the volume specified, CHEAPO II interprets the removal to be a precommercial thinning operation (a cost).

Units/Species:	Blank.
Field 1:	Enter average tree size expressed as a quadratic mean diameter limit (such as 10.4). . . . Default is 0.0 inch.
Field 2:	Enter the volume-per-acre removal limit in the unit of volume defined on the analysis-type keyword record. . . . Default is 0.0 volume units as specified on the analysis-type keyword record.
Fields 3-12:	Blank.

In many cases the user will probably have a good idea from past experience as to whether the removals scheduled in the Prognosis Model projection are precommercial thinning or other thinning and harvest operations. In cases where the user has no such past experience, the Prognosis Model may have to be executed and results evaluated prior to specifying tree size and/or volume standards.

Only one of the selection criteria may actually be needed to differentiate between types of operations. For example, suppose the user knows that the minimum amount of volume per acre that needs to be removed in order to justify a harvest is 2.0 M bd ft. The user can then specify an artificially high diameter limit (such as 99.9 inches) and the 2.0 M bd ft breakpoint. In this case, only the board foot volume standard effectively acts as the cutoff level to distinguish a precommercial thinning from a commercial operation. Because the diameter limit is never met, all harvests that remove more than 2.0 M bd ft per acre will be treated as a commercial operation. Also, if only a diameter breakpoint is known, the user can specify an artificially large volume limit (such as 999 M bd ft). In this case only the diameter breakpoint will be relevant. Of course, the user who understands the breakpoints for these criteria can use both. Artificially low values for both criteria will ensure that all removals are treated as commercial operations, and artifically high values will ensure that all removals will be treated as precommercial thinnings.

Thinning and Harvest Costs.—Thinning and harvest costs can be specified using two types of keywords for each treatment. Thinning costs are assigned to precommercial thinning operations as identified by the THINSPEC keyword. Harvest costs are assigned to other thinning and harvest operations only. Keywords specify whether the costs are to be treated as fixed or as variable. **Fixed costs do not vary with the amount of timber removed. Variable costs change with the amount removed.** For example, machinery setup costs would usually be fixed costs, but felling/bucking costs would be variable. The first two keywords are used to designate fixed treatment costs. The second two keywords

are used to designate variable costs. Fixed costs are always expressed on a per-acre basis. Variable costs can be expressed as per thousand trees or per unit of volume.

Up to six diameter size classes with different variable costs may be specified. There is no allowance for differences in variable costs by species. It is not necessary that all diameter size classes have the same unit of measure. For example, costs for small-sized materials might be expressed on a per-thousand-trees basis while large-sized material may be expressed per M bd ft. **Up to six diameter size class limits may be entered, each to the nearest whole inch.** If more than six classes are specified, only the first six are recognized by CHEAPO II. Fixed and variable costs are entered with keyword and field parameters as follows:

FIXTCOST — Fixed precommercial thinning cost assignment on a per-acre basis.

FIXHCOST — Fixed harvest cost assignment on a per-acre basis.

- Units/Species: Blank (understood on a per-acre basis).
- Field 1: Current (today's) per-acre value for fixed cost (such as 197.15).
- Field 2: Blank.
- Fields 3-12: Value rate changes and durations.

THINCOST — Variable precommercial thinning cost assignment.

HARVCOST — Variable harvest cost assignment.

- Units/Species: Enter TA=1,000 trees; BF=1,000 bd ft; and CF=100 ft^3.
  . . . Default measure is CF.
- Field 1: Current (today's) per-unit value of cost (such as 19.75).
- Field 2: Smallest diameter size class to which costs apply. Up to six diameter size classes may be used—each diameter size class specified requires a separate THINCOST or HARVCOST record.
- Fields 3-12: Value rate changes and durations.

Annual Costs.—Annual costs can be specified as one of three types: overhead, forest protection, and administration. Annual costs are fixed costs, expressed on a per-acre basis. Keywords and field parameters are as follows:

OVERHEAD — Overhead costs.

FPROTECT — Forest protection costs.

ADMINIST — Administration costs.

- Units/Species: Blank (always on an annual, per-acre basis).
- Field 1: The current (today's) value of annual costs on a per-acre basis (such as 7.62).
- Field 2: Blank.
- Fields 3-12: Value rate changes and durations.

NOTE: The three specified classes of annual costs are all handled by CHEAPO II in the same way. If the user has an annual cost that does not correspond to one of the three types specified above, the cost can be entered as if it were one of these types of headings, but the heading used to label output would have to serve as a surrogate for the correct heading. **The user must keep track of this label alteration.**

Special Costs.—Special costs, unlike annual costs, can occur at any user-specified point in time. For example, planting activities not associated with the regeneration establishment extension could be entered as a special cost. **Up to 10 individual special costs can be entered.** If more than 10 are entered, only the first 10 will be recognized.

Each special cost is entered on its own keyword record. If the year of occurrence for a special cost is outside the analysis time horizon, it is ignored. When the year of occurrence is not at the beginning of a cycle and the unit of measure specified is other than per acre, the number of trees per acre or volume measure used to calculate the cost will be based on the **stand conditions at the beginning of the cycle after scheduled tree removals.** When the year of occurrence is at the beginning of a cycle, the stand conditions after scheduled tree removals are used. If the analytical procedures just described portray incorrectly the special cost activity, the resulting calculations will also be incorrect. This problem can be remedied if the user enters special costs on a per-acre basis.

If more than 10 special costs are needed, additional cost values can be specified by assigning negative values to special revenues. But only up to a total of 10 special revenues can be used. Note, however, that **by including costs as a negative revenue, the resulting benefit-cost ratio will be incorrect.** The keyword and field parameters are as follows:

SPECCOST Special cost.

	Units/Species:	Unit to which value applies (AC=per acre; CF=100 ft^3; BF=1,000 bd ft; TA=1,000 trees per acre). . . . Default measure is AC.
	Field 1:	Current (today's) value of cost per unit.
	Field 2:	Year of occurrence.
	Fields 3-12:	Value rate changes and durations.

Prognosis Model Extensions.—CHEAPO II currently recognizes two Prognosis Model extensions: the Douglas-fir Tussock Moth Outbreak Model and the Regeneration Establishment Model. Keywords used by CHEAPO II to link economic information with the management treatments available in the extensions are the same keywords used in the extensions.

There are currently six management activities that can occur when Prognosis Model extensions are evoked that also can be analyzed by CHEAPO II. Costs can be assigned to these events and a cost will apply when an event occurs within the Prognosis Model projection. **A total of 20 separate occurrences of these events can be analyzed.** If more than 20 are encountered, the excess is ignored by CHEAPO II.

Douglas-fir Tussock Moth Outbreak Model.—The Douglas-fir Tussock Moth Outbreak Model (Monserud and Crookston 1982) allows for three treatment keywords, two corresponding to viral and the other to chemical control applications. The cost of each treatment can be specified for use in the economic analysis when the Outbreak Model is evoked. The keywords refer to specific treatment options available within this Prognosis Model extension. For a description of these treatments, see Monserud and Crookston (1982, pp. 16-18). **Treatment costs are always expressed on a per-acre basis.** For the economic analysis, the keywords and field parameters are as follows:

NPV2 Nuclear polyhedrosis virus treatment applied in phase II.

NPV3 Nuclear polyhedrosis virus treatment applied in phase III.

CHEMICAL Chemical control.

Units/Species:	Blank (understood on a per-acre basis).
Field 1:	Current (today's) per-acre cost of the treatment.
Field 2:	Blank.
Fields 3-12:	Value rate changes and durations.

Regeneration Establishment Model.—The Regeneration Establishment Model (Ferguson and Crookston 1984) allows for three treatment keywords that can be specified as cost items in the economic analysis. The keywords refer to three specific treatment options available within the Regeneration Establishment Model—MECHPREP, BURNPREP, and PLANT. For a description of the keywords, see Ferguson and Crookston (1984, pp. 10-12). **Costs associated with MECHPREP and BURNPREP must be expressed on a per-acre basis, and costs associated with PLANT may be expressed either on a per-acre or per-thousand-trees-planted basis.** For the economic analysis, the keywords and the field parameters are as follows:

MECHPREP Site preparation using mechanical scarification.

BURNPREP Site preparation using burning.

PLANT Planting.

Units/Species:	Unit to which value applies (AC=per acre; TA=1,000 trees per acre). . . . Default measure is AC.
Field 1:	Current (today's) per-acre cost of the treatment.
Field 2:	Blank.
Fields 3-12:	Value rate changes and durations.

In the Regeneration Establishment Model, the user has the flexibility to specify the percentage of the stand to be treated by burning and/or mechanical scarification. The single acre representing the stand can then be divided into percentages burned, scarified, or left untreated. **CHEAPO II will compute a weighted per-acre cost for these treatments, based on the percentage of the area in each treatment.** Therefore the per-acre costs entered in the MECHPREP and BURNPREP keyword records should reflect costs of treating the entire acre.

Harvest Revenues.—Revenues associated with a commercial thinning or with harvest operations can be entered for **up to six diameter size classes per species.** The user should pay particular attention to correctly matching cost and revenue items, especially when revenue is construed as stumpage value. Diameter size class limits are entered to the **nearest whole inch.** Trees are grouped by diameter size class, and the revenue associated with each species size class combination is applied in computing revenues. If more than six size classes are entered for any species only the first six will be used. Each of the six diameter size classes per species specified requires a separate keyword record. **The user must specify appropriate lower diameter limits for each diameter size class.** Diameter limits can be arranged in any order in the record file: ascending, descending, or mixed. CHEAPO II will sort and order them.

The following is an example of how diameter size classes are determined. If two diameter classes (8-inch and 10-inch) are specified for a species, two revenue keywords would be used. The revenue record corresponding to the 8-inch diameter class limit would apply to all trees 8 to 10 inches in diameter. Correspondingly, the 10-inch diameter class revenue record would apply to all trees 10 inches and larger. A tree at the diameter size class boundary is included in the larger diameter class.

The keyword and field parameters are as follows:

REVENUE Revenue assignment for tree removals.

Units/Species:	Species code (see species codes in appendix B). . . . Default species is OT. *NOTE:* Also see appendix B for instructions on modifying the species code list with revenue assignments.
Field 1:	Current (today's) value per unit for revenues. The value should be expressed in the same unit of volume measure indicated on the analysis-type keyword record (such as BF or CF).
Field 2:	Smallest diameter size class to which the revenue applies.
Fields 3-12:	Value rate changes and durations.

Special Revenues.—Special revenue is the revenue counterpart to the special costs keyword. Special revenues can occur at any user-specified point in time. **Up to 10 special revenues can be entered**. If more than 10 are entered, only the first 10 will be recognized. Like special costs, more than 10 special revenues can be entered by "tricking" CHEAPO II; additional revenues can be entered by treating them as negative special cost values. Nevertheless, only a total of 10 special costs can be used. **As in the case of special costs, this convention will result in an incorrect B/C Ratio**. If the year of occurrence for a special revenue is outside the analysis time horizon, it is ignored. When the year of occurrence is not at the beginning of a cycle and the unit of measure specified is other than per acre, the number of trees per acre or volume measure used to calculate the revenue will be based on the **stand conditions at the beginning of the cycle after scheduled tree removals**. When the year of occurrence is at the beginning of a cycle, the stand conditions after scheduled tree removals are used. The keyword and field parameters are as follows:

SPECREVN Special revenue.

Units/Species:	Unit to which value applies (AC=per acre; CF=100 ft^3; BF=1,000 bd ft; TA=1,000 trees per acre). . . . Default measure is AC.
Field 1:	Current (today's) value of revenue per unit.
Field 2:	Year of occurrence.
Fields 3-12:	Value rate changes and durations.

The Discount Rate.—Another economic assumption keyword assigns the annual discount rate, the annual rate of compound interest used in all present value calculations. The discount rate used can be expressed in either real or nominal terms. From a computational standpoint, CHEAPO II treats nominal and real discount rates identically. The user is solely responsible for correctly making the distinction. **A nominal discount rate includes inflation as a component; a real rate has the inflation component removed.** Interest rates observed in most everyday occurrences are nominal; they include an inflationary component. Nominal rates include interest rates paid on savings accounts, home mortgages, money market accounts, and so on. The methodology for eliminating the inflationary component from a nominal rate to obtain real rate is as follows:

$$r = \left[\frac{1 + n}{1 + i}\right] - 1.0$$

where

r = the annual real discount rate (in decimal form)

n = the annual nominal discount rate (in decimal form)

i = the annual rate of inflation (in decimal form).

A measure of the rate of inflation can be derived from any number of indexes used to measure inflation, including the Producer Price Index, the Consumer Price Index, or the Gross National Implicit Price Deflator. For a further discussion of these indexes and computational procedures, see Gunter and Haney (1984). **Only one discount rate can be applied per analysis.** If more than one discount rate is entered, the first one encountered is used. The keyword and field parameters are as follows:

DISCOUNT Discount rate to be used in economic analysis.

Units/Species:	Unit to which discount rate applies (RE=real; NO=nominal).
	. . . Default measure is blank.
	. . . Note: Discount rate code is used to label output only and does not affect computations.
Field 1:	Discount rate as a percentage (such as 5.55).
Fields 2-12:	Blank.

Value Rate Changes and Durations.—Cost and revenue levels may change over time with changes in economic markets and conditions. Such changes are referred to as value rate changes and are usually measured relative to the general level of prices. For example, if the value of a particular item increases faster than the general level of prices, it is said to be reflecting a "real" value change. **Up to a total of five different value rate changes and durations can be specified for each cost and revenue item. Value rate changes may be positive (increasing values) or negative (decreasing values).**

Value rate changes are entered as percentages. Durations are entered in whole years. If fractional years are entered, the fractional component is ignored. A duration field left blank, or entered as 0 or 999, is interpreted to be infinity. If no value rate changes are specified, the original value entered is interpreted to remain constant over time.

Like the discount rate, value rate changes can be expressed in either real (inflation is netted out) or nominal (includes inflation) terms. The user, however, must be consistent in the use of nominal or real discount and value rate changes. **Mixing real and nominal rates is an incorrect analytical procedure.** For example, CHEAPO II cannot interpret a difference between a real and a nominal rate for discounting and value rate changes. If the user specifies a discount rate in nominal terms and value rate changes in real terms, CHEAPO II cannot recognize this procedural inconsistency and the resulting output will be analytically incorrect. Moreover, if the user specifies a nominal discount rate, a value rate change must be specified for every cost and revenue item, at least reflecting the inflationary component of the nominal discount rate.

Care should be taken when specifying rate durations with the PNVPLUS and SEVANAL analysis-types. With these two types of analysis, the discounted value of individual rotations or cutting regimes must be recalculated by CHEAPO II one at a time until rate durations become constant. Only then can

CHEAPO II correctly apply an infinite series calculation to remaining rotations or cutting periods. **Unrealistically long and/or complex value rate change combinations could greatly increase computing time.**

Each cost and revenue may have up to five rate/duration combinations specified in numeric fields 3-12. In all cases, the first two rate/duration combinations are specified in fields 3-6. Additional rates can be specified by entering a C in the continuation field and three additional rate/duration combinations on the supplemental record in fields 7-12. **If a negative rate is to be specified, the percentage rate is simply preceded by a negative (−) sign, without space between it and the rate.** The negative sign uses one of the available columns. If a positive rate is to be specified, a plus (+) sign is not necessary. In all cases, the keyword field, units/species field, and numeric fields 1 and 2 are used to define the cost or revenue information to which the value rate changes and durations apply.

Field parameters are as follows:

Record	Field	Content
Keyword	Keyword:	Already used
	Units/Species:	Already used
	Fields 1 & 2:	Already used
	Field 3:	1st value rate change
	Field 4:	Duration of 1st rate
	Field 5:	2d value rate change
	Field 6:	Duration of 2d rate
	Continuation:	Continuation designation
Supplemental	Field 7:	3d value rate change
	Field 8:	Duration of 3d rate
	Field 9:	4th value rate change
	Field 10:	Duration of 4th rate
	Field 11:	5th value rate change
	Field 12:	Duration of 5th rate

Sensitivity Analysis.—The final economic assumption keyword is for conducting a sensitivity analysis. Given a specified management regime for a stand, the Prognosis Model projects the stand through time. If an economic analysis is undertaken, the user specifies analysis instructions by entering appropriate keyword records and relevant keyword parameters. These parameters should reflect, as accurately as possible, the current and perceived future market conditions the user faces in undertaking the proposed investment. In terms of a sensitivity analysis, the above parameters are referred to as a "base case" analysis. Given the Prognosis Model projection and the CHEAPO II economic assumptions specified, the user will obtain economic analytical results.

It is often useful to determine how "sensitive" the base case analytical results are to the economic assumptions specified. For example, if a relatively small change in an economic assumption greatly alters the analytical results, the analysis is said to be highly sensitive to the assumption. In such cases, greater care should be taken in making sure the assumption is accurate.

Furthermore, because investment analyses necessitate projections of future events, users are subject to all of the uncertainties of forecasting. In an attempt to obtain a range of possible investment results, it is often useful to undertake an analysis based on "optimistic" assumptions and one based on "pessimistic" assumptions in addition to the base case analysis. A sensitivity analysis may be used to accomplish this task.

A sensitivity analysis is initiated by the SENSANAL keyword. Information to be changed is entered on applicable economic assumption keyword records immediately following the SENSANAL keyword record. Given the changes specified, CHEAPO II recalculates and displays the additional analytical results. **Because the new record in the sensitivity analysis replaces previously specified data, all fields on the record being modified must be reentered.**

The user may test the sensitivity of any one or any combination of the economic assumptions specified in the base case analysis, with the exceptions of diameter limits, year of occurrence, and analysis type. There is no maximum number of changes that can be made in any given sensitivity analysis, and there is no limit on the number of individual sensitivity analyses that can be undertaken. But the effects of each successive sensitivity analysis on the base case assumptions are cumulative. That is, **once an assumption has been changed by a sensitivity analysis, the change remains in effect for all subsequent sensitivity analyses, unless again changed**. All sensitivity changes remain in effect within a single analysis, but once a new analysis is initiated (as in multiple projections or multiple analyses discussed later), all previously specified sensitivity changes are canceled and the analysis begins afresh.

The keyword and field parameters are entered as follows:

SENSANAL Sensitivity analysis.
Other fields: Blank.

Program Execution Keywords

Program execution keywords are designed to provide the user with flexibility in the execution of options available in CHEAPO II. When any of these keywords are used, **no information is entered in any other field**.

CHEAPO Unlike Prognosis Model extensions, CHEAPO II does not interact dynamically with the Prognosis Model. It does, however, use special Prognosis Model output as input (Wykoff and others 1982, p. 86). In order to generate this special Prognosis Model output, **the keyword CHEAPO must be included in the Prognosis Model keyword file.** The keyword CHEAPO is a Prognosis Model keyword, not a CHEAPO II keyword.

PROCESS Following a set of economic assumption keyword records, the PROCESS keyword is entered to indicate that economic calculations are to be conducted for a single economic analysis for a single Prognosis Model stand projection. When using the sensitivity analysis feature, **the SENSANAL keyword record follows the PROCESS keyword record for the initial (base case) part of the file. Also, each sensitivity analysis must begin with a SENSANAL keyword record and end with a PROCESS keyword record.**

ENDSTAND When the end of the CHEAPO II keywords for analysis of a particular stand has been reached, the ENDSTAND keyword must be entered. The ENDSTAND keyword results in display of requested stand table information and resets program default values for analysis of additional stands.

REWIND In addition to the ability to analyze several stands in a single job stream, CHEAPO II can do several analyses when processing a single stand by using the REWIND keyword. The REWIND keyword follows the PROCESS and ENDSTAND keywords. Although the user is limited to the economic assumptions that can be

	changed for sensitivity analyses, **REWIND allows the user to initiate a new economic analysis, including analysis-type**.
STOP	The last keyword available is the STOP keyword. This keyword signals the end of the input file.

Program Output Keywords

CHEAPO II output is displayed in two types of output tables—economic analysis and stand tables. Some tables are automatically printed; others need to be requested by the user through a keyword record. Variation in table content is controlled through the selection of analysis-type, rate of return and table suppressions, and sensitivity analysis options.

The economic analysis output consists of a series of three tables that are automatically printed by CHEAPO II. Output Table 1—Economic Assumptions for Stand Analysis—provides a listing of the economic assumptions used in the analysis. Output Table 2—Undiscounted Cash Flow Summary—is a chronological listing of the management treatments undertaken and the undiscounted costs and revenues associated with each management treatment. Output Table 3—Economic Analysis Summary—displays the results of an economic analysis.

The output of any of these tables may be suppressed. The keywords to suppress these output tables are:

NOTABLE1 NOTABLE2 NOTABLE3	Keywords to indicate that the table is not to be output. No information is entered in the fields.

If suppressed, the printing of the tables can be later reactivated by using the keywords:

TABLE1 TABLE2 TABLE3	Keywords to reactivate a suppressed output table. No information is entered in the fields.

As discussed earlier regarding SENSANAL changes, the above keywords will remain in effect either until specifically changed or until a new analysis is initiated, at which time the default values are again assigned.

An optional set of tables that produce stand table information, as summarized for use in the economic analysis, can also be requested. Tabular information includes a summary by species and size class for each projection cycle. The units (BF or CF) and size classes displayed are based on the parameters entered on the REVENUE, THINCOST, and HARVCOST keywords. Values are displayed for the stand before removals and for any removals that occur. Only species with trees present during the projection are reported. Stand tables cannot be requested with a sensitivity analysis. But the use of the SENSANAL option does not prevent the user from requesting stand tables from the base case analysis. This optional set of tables will be produced only when the user requests them with the following keyword:

STDTABLE	No information is entered in the fields.

Two keywords are available to control calculation and output display of the rate of return (ROR) for all analysis types. ROR is calculated using an iterative method, starting with a discount rate of 0.0 for each cycle. A large number of iterations will probably be necessary before ROR has been identified. For this reason, ROR calculation can be suppressed and reinitiated by keywords. **The default action for ROR is calculation**. The keywords used to control ROR calculations are:

NOROR Suppress ROR calculation.

ROR Reinitiate ROR calculation if previously suppressed.

The last keywords available are used to produce a textual comment section for documentation of individual analysis assumptions. For example, the user may want to describe the specific costs associated with a SPECCOST keyword. Comment text is initiated by the keyword COMMENT and ended by the keyword END. The text appearing between these keywords will be reproduced, verbatim, in the comment section. There are no restrictions to the number or format of text records, except that **comment text must be contained between columns 1 and 72 on each record and that the first three columns cannot contain the word "END" if the fourth column is blank**. If the keyword END is omitted from the keyword file, all subsequent records, including keyword records, will be interpreted by CHEAPO II as being part of the comment text. Multiple sets of comment text can be produced by multiple sets of COMMENT and END keyword records. The comment section output is printed in conjunction with output Table 3—Economic Analysis Summary. The keywords used to control the comment section are:

COMMENT To indicate the beginning of comment section text.

END To indicate the end of comment section text.

INPUT FILE EXAMPLES

The following input examples are not exhaustive of the potential combinations of keywords available to the user. They serve merely to illustrate the types of analyses that can be undertaken and various input file manipulations that can be performed. The examples are designed to serve two purposes. The first purpose is to illustrate the input format of the keyword records. The second purpose is to illustrate the recommended ordering of the keyword input file. For some keywords, such as the analysis-type keywords (PNVANAL, SEVANAL and PNVPLUS) and program execution keywords (PROCESS, ENDSTAND, SENSANAL, REWIND, and STOP), specific ordering is necessary. Where particular attention is focused on a keyword or other input feature, it will be highlighted with an arrow.

CHEAPO II File From Prognosis Model

If the user is going to use the Prognosis Model to project a forest stand and then undertake an economic analysis of the simulation using CHEAPO II, it is necessary to enter the keyword CHEAPO in the Prognosis Model input file (exhibit 1). This keyword must be placed before the PROCESS keyword record in the Prognosis Model input file. This keyword instructs the Prognosis Model to create a special output file of the management treatments and yields projected by the Prognosis Model, thus creating an input file to be used by CHEAPO II.

Analysis of a Single Projection

Exhibit 2 illustrates an example input file for a single economic analysis of a single Prognosis Model projection.

Keyword PNVANAL indicates the analysis type and that the units/species designation of species volume measure is to be 1,000 bd ft. Other analysis-type keywords include SEVANAL and PNVPLUS.

The COMMENT and END keyword records indicate the beginning and ending of textual comments. The materials appearing between the keyword records are used to document analysis features.

```
                                         COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

STDIDENT
EXAMPLE   PROGNOSIS MODEL EXAMPLE FOR CHEAPO II USER'S GUIDE
MGMTID
RUN
NOTREES
STDINFO           18       530                 5         2        30
DESIGN            20         1         99      1         0
INVYEAR         1985
NUMCYCLE           8
ESTAB           1985
MECHPREP        1985       100
PLANT           1985         1        500
PLANT           1985         2        100
STOCKADJ        1985       0.0
END
CHEAPO
PROCESS
STOP
```

Exhibit 1.—The keyword CHEAPO in the Prognosis Model input file.

```
                                         COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST  BF   98.00       7.0
REVENUE   L   145.00       7.0       2.0       10.0
REVENUE   L   165.00       9.0       2.0       10.0
REVENUE   WP  180.00       7.0       2.0       10.0
REVENUE   WP  195.00      12.0       2.0       10.0       1.0      10.0 C
                 2.0      10.0       3.0
REVENUE   WP  255.00      15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT  RE     4.0
STDTABLE
PROCESS
ENDSTAND
STOP
```

Exhibit 2.—Example of an input file to analyze a single projection.

Keywords ADMINIST and FPROTECT indicate an annual cost of \$2.10 for administration and \$0.50 for forest protection. Both costs are understood to be on a per-acre per-year basis.

Keywords MECHPREP and PLANT indicate mechanical site preparation of \$50 per acre and planting costs of \$250 per acre. There are several methods for regenerating stands (Ferguson and Crookston 1984). If a stand establishment treatment that incurs a cost is used in the Prognosis Model projection, however, the user must specify this cost by using the appropriate keyword and values in the CHEAPO II input file.

Keyword HARVCOST indicates a harvesting operation cost of \$98/M bd ft for all trees greater than or equal to 7.0 inches diameter.

The REVENUE keyword records indicate the values, diameter size class specifications, and the amounts and durations of value rate changes for two species. The first revenue record assigns a value of $145/M bd ft for all western larch removed that have a diameter greater than or equal to 7.0 inches and less than the next diameter size class limit specified. This first revenue record also assigns a value rate change of 2.0 percent per year for 10 years. The revenue value will be increased at 2.0 percent per year for the first 10 years and will remain constant thereafter. The second revenue record assigns a value of $165/M bd ft for all western larch removed that have a diameter greater than or equal to 9.0 inches, and assigns a value rate change of 2.0 percent per year for the first 10 years. This second diameter size class specification for western larch now limits the specification on the first revenue record. Given the presence of the second record, the first record, in effect, assigns a value of $145/M bd ft on those western larch trees removed that have a diameter greater than or equal to 7.0 inches but less than 9.0 inches. The third, fourth, and fifth revenue records assign values for different diameter size classes of white pine. The revenue assignments are as follows: $180/M bd ft for trees 7.0 inches to less than 12.0 inches in diameter; $195/M bd ft for trees 12.0 to less than 15.0 inches; and $255/M bd ft for trees greater than or equal to 15.0 inches in diameter. All three diameter size classes for white pine assign a value rate change of 2.0 percent per year for the first 10 years. The 12.0 to less than 15.0-inch diameter size class, in addition to assigning a 2.0 percent per year value rate change for the first 10 years, also assigns a 1.0 percent per year rate change for the next 10 years (the C indicates the rate changes and durations are continued on a supplemental record), a 2.0 percent per year rate change for the next 10 years, and a 3.0 percent per year value rate change for the remainder of the investment time horizon. (Note: If the analysis-type were SENSANAL or PNVPLUS, the investment time horizon would be infinity.)

The DISCOUNT keyword record establishes the annual discount rate at 4.0 percent and the designation RE indicates a real discount rate.

The STDTABLE keyword record requests an optional set of output tables that produce stand table information.

The PROCESS keyword record indicates that economic analysis calculations are to be done using the information and instructions provided on previous keyword records.

The ENDSTAND keyword record indicates that the end of the input for an individual analysis has been reached.

The STOP keyword record indicates the end of the CHEAPO II input file.

Sensitivity Analysis

Exhibit 3 shows an input file for PNVANAL, including a series of sensitivity analyses.

The SENSANAL keyword record follows the PROCESS keyword record of the base case input file and indicates that a sensitivity analysis is to be undertaken by changing one or any combination of the assumptions specified previously. This example has two different sensitivity analyses. The first sensitivity analysis uses the keyword DISCOUNT to change the discount rate from 4.0 to 6.0 percent. All other base case input file specifications remain the same as originally specified. This sensitivity analysis also uses the keyword NOTABLE2 to suppress the printing of output Table 2—Undiscounted Cash Flow Summary—and NOROR to suppress the calculation of the rate of return.

The keyword PROCESS indicates that economic analysis calculations are to be done and marks the end of the first sensitivity analysis.

```
                                          COLUMNS
             1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST  BF   98.00       7.0
REVENUE   L   155.00       7.0       2.0       10.0
REVENUE   WP  190.00       7.0       2.0       10.0
REVENUE   WP  255.00      15.0       2.0       10.0
DISCOUNT  RE     4.0
STDTABLE
PROCESS
SENSANAL
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SENSITIVITY ANALYSIS 1
      1) DISCOUNT RATE 6 PERCENT
END
NOTABLE2
NOROR
DISCOUNT  RE     6.0
PROCESS
SENSANAL
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SENSITIVITY ANALYSIS 2
      1) DISCOUNT RATE 6 PERCENT
      2) PLANTING COSTS $300 PER ACRE
END
PLANT         300.00
TABLE2
ROR
PROCESS
ENDSTAND
STOP
```

Exhibit 3.—Example of a sensitivity analysis input file.

The second sensitivity analysis uses the keyword PLANT to change the cost of planting from $250 to $300 per acre. It also uses the keyword TABLE2 to reactivate the printing of output Table 2—Undiscounted Cash Flow Summary—and the keyword ROR to reactivate the calculation of rates of return. If a table is deactivated or the calculating of rates of return is deactivated, this will be done for all subsequent analyses unless the user reactivates the option. Because the effect of sensitivity analyses on changes in base case economic assumptions is cumulative, the discount rate used in the second sensitivity analysis will be 6.0 percent, reflecting the change made by the first sensitivity analysis.

As before, the keyword PROCESS marks the end of the sensitivity analysis.

The keyword ENDSTAND indicates that the end of an individual economic analysis (including each sensitivity analysis) for a particular stand projection has been reached.

The STOP keyword indicates the end of the CHEAPO II input keyword file.

Analysis of Multiple (or Stacked) Projections

In the output created by the Prognosis Model to be used as an input file for CHEAPO II, the user may indicate the results of more than one Prognosis Model projection. The results of several projections can be "stacked," as previously shown in figure 8. Exhibit 4 shows an example of an input file to undertake a present net value analysis on two separate projections, separated by an ENDSTAND keyword record.

```
                                       COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

PNVANAL  BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- FIRST OF 2 STACKED STANDS

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST BF    98.00       7.0
REVENUE  L    145.00       7.0       2.0       10.0
REVENUE  L    165.00       9.0       2.0       10.0
REVENUE  WP   180.00       7.0       2.0       10.0
REVENUE  WP   195.00      12.0       2.0       10.0       1.0       10.0 C
                 2.0      10.0       3.0
REVENUE  WP   255.00      15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT RE      4.0
STDTABLE
PROCESS
ENDSTAND
PNVANAL  BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SECOND OF 2 STACKED STANDS

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST BF    98.00       7.0
REVENUE  L    145.00       7.0       2.0       10.0
REVENUE  L    165.00       9.0       2.0       10.0
REVENUE  WP   180.00       7.0       2.0       10.0
REVENUE  WP   195.00      12.0       2.0       10.0       1.0       10.0 C
                 2.0      10.0       3.0
REVENUE  WP   255.00      15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT RE      4.0
STDTABLE
PROCESS
ENDSTAND
STOP
```

STACK NO.1

STACK NO.2

Exhibit 4.—Example for multiple (or stacked) projections.

The keyword ENDSTAND preceded by the keyword PROCESS marks the end of each individual economic analysis, at which time all analysis assumptions revert to default values. **There is no limit to the number of stands that can be stacked.** Because one economic analysis is distinct from the other, it would also be possible to do different analysis-types (PNVANAL on the first projection and SEVANAL on the second projection).

Multiple Analyses for a Single Projection

On any single stand projected, only one analysis-type can be executed by CHEAPO II unless the Prognosis Model-created input file is rewound to be used again by CHEAPO II. Exhibit 5 shows an input file example of two analysis-types being done on a single projection: a present net value analysis and a soil expectation value analysis. Again, separation is accomplished with an ENDSTAND keyword record.

The PNVANAL keyword marks the beginning and the keywords. PROCESS and ENDSTAND mark the end of the present net value analysis.

```
                                                COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================
```

ANALYSIS NO.1

```
PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- FIRST ANALYSIS OF 2

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST  BF   98.00       7.0
REVENUE   L   145.00       7.0       2.0       10.0
REVENUE   L   165.00       9.0       2.0       10.0
REVENUE   WP  180.00       7.0       2.0       10.0
REVENUE   WP  195.00      12.0       2.0       10.0       1.0      10.0 C
                 2.0      10.0       3.0
REVENUE   WP  255.00      15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT  RE     4.0
STDTABLE
PROCESS
ENDSTAND
REWIND
SEVANAL   BF    1985
```

ANALYSIS NO.2

```
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SECOND ANALYSIS OF 2

      1) ECONOMIC ANALYSIS TYPE IS SOIL EXPECTATION VALUE (SEVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST  BF   98.00       7.0
REVENUE   L   145.00       7.0
REVENUE   L   165.00       9.0
REVENUE   WP  180.00       7.0
REVENUE   WP  195.00      12.0
REVENUE   WP  255.00      15.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT  RE     4.0
PROCESS
ENDSTAND
STOP
```

Exhibit 5.—Example for multiple analysis types on a single stand.

The keyword REWIND executes the rewinding of the Prognosis Model generated input file. This is the critical keyword record for conducting multiple analyses on a single Prognosis Model projection. The instructions for one analysis precede the REWIND keyword; instructions for the next analysis follow it. There is no limit to the number of analyses that can be conducted on a single projection if the REWIND keyword is used repeatedly. Each set of instructions stands alone, with no carry over of instructions from one analysis to another.

The keyword SEVANAL marks the beginning and the keywords PROCESS and ENDSTAND mark the end of the soil expectation value analysis.

The keyword STOP indicates the end of the input keyword file.

OUTPUT EXAMPLES

CHEAPO II output is displayed in two types of tables—economic analysis tables and stand summary tables. Some of these tables are automatically printed, while others need to be called for by keyword records. Variation in

table content is controlled through selection of analysis-type, rate of return and table suppressions, and sensitivity analysis options.

Economic Analysis Tables

The economic analysis tables are automatically included in CHEAPO II output. Through the use of keywords, these tables may be suppressed or expanded. Economic analysis output consists of a set of three tables. Each table heading is designated by a numerical designation of the table type: Table 1 for economic assumptions for stand analysis, Table 2 for undiscounted cash flow summary, and Table 3 for economic analysis summary. The initial numerical designation of the table type is followed by another numerical designation indicating whether the tabled information refers to the base case analysis (0) or a sensitivity analysis (1=the first sensitivity analysis, 2=the second sensitivity analysis, and so on).

Economic Assumptions for Stand Analysis: Table 1.—Output Table 1 lists the economic parameters used in the analysis. It is useful for keeping track of the parameters specified by the user and for checking that the parameters were entered correctly.

Exhibit 6 illustrates output Table 1-0 for a present net value analysis. The column labeled ITEM is a listing of the analysis-type keywords, economic assumption keywords, and the output control keywords specified in the input file. Program execution keywords are **not** included in this table.

The UNITS column is a listing of the units of measure specified for the corresponding keyword. These include YR (annual), BF (thousand board feet), CF (hundred cubic feet), AC (acre), and TA (per 1,000 trees).

SPECIES lists the species codes specified on the REVENUE keyword records. Species codes listed correspond to those shown in appendix B.

TABLE 1- 0. ECONOMIC ASSUMPTIONS FOR STAND ANALYSIS

ITEM	UNITS	SPECIES	DATE	LIMITS MIN DBH	LIMITS VOLUME	CURRENT VALUE	VALUE RATE CHANGES AND DURATIONS %	FOR YEARS	%	FOR YEARS
PNVANAL	BF									
ADMINIST	YR					2.10	.0	0		
FPROTECT	YR					.50	.0	0		
MECHPREP	AC					50.00	.0	0		
PLANT	AC					250.00	.0	0		
SPECCOST	AC		1990			35.00	.0	0		
HARVCOST	BF			7		98.00	.0	0		
REVENUE	BF	L		7		145.00	2.0	10		
REVENUE	BF	L		9		165.00	2.0	10		
REVENUE	BF	WP		7		180.00	2.0	10		
REVENUE	BF	WP		12		195.00	2.0	10	1.0	10
						ADDITIONAL RATE/DURATION			2.0	10
						ADDITIONAL RATE/DURATION			3.0	0
REVENUE	BF	WP		15		255.00	2.0	10		
DISCOUNT						4.00 % REAL				
STDTABLE										

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 6.—Table 1 output for a present net value analysis.

The column labeled DATE lists the dates as specified on the SEVANAL, PNVPLUS, SPECREVN, and SPECCOST keyword records. The columns labeled LIMITS list diameter and volume specifications. The subcolumn MIN DBH refers to minimum diameter size class specifications. This column is appropriate to REVENUE, THINSPEC, HARVCOST, and THINCOST keyword records. The subcolumn VOLUME refers to minimum volume specifications used with the THINSPEC keyword record only.

The CURRENT VALUE column lists the current values of costs, revenues, and the discount rate specified. This column is appropriate for all of the economic assumption keyword records except for the keyword THINSPEC, which contains no cost or revenue information.

VALUE RATE CHANGES AND DURATIONS is a listing of the value rate changes and their durations specified for each economic assumption. Up to five rates and durations may be used for each economic assumption keyword.

The first group of listings in output Table 1-0 reflects the initial assumptions in the input file. When this listing is complete it is set off by a dotted line. Following this line, the standard identifications that were specified in the Prognosis Model projections are printed. These include the stand and management identifications.

If a sensitivity analysis was undertaken, a new output Table 1-1 would be printed and would include a listing of only the economic assumptions changed from the base case analysis in the first sensitivity analysis (exhibit 7).

The format of output Table 1—Economic Assumptions for Stand Analysis—for a soil expectation value analysis and for a present net value plus analysis is identical to that described above, with minor exceptions. For the soil expectation value analysis, ANALYSIS BASE YEAR: _____ is printed immediately following the SEVANAL keyword and the unit of volume measure specified. This is the year specified on the SEVANAL keyword record to establish the beginning year of the soil expectation value analysis (investment year zero). For the present net value plus analysis, REPEATABLE MANAGEMENT REGIME ASSUMED: _____ TO _____ is printed immediately following the PNVPLUS keyword record and the unit of volume measure specified. These are the years specified on the PNVPLUS keyword record as the beginning and ending dates of the repeatable management regime.

Undiscounted Cash Flow Summary: Table 2.—Economic analysis results are shown in output Table 2 (exhibit 8). They consist of a chronological listing of the management treatments undertaken and the undiscounted costs and revenues associated with each treatment. This shows the actual magnitudes of future undiscounted cash flows (in either real or nominal terms) associated with the management treatments projected.

```
TABLE 1- 1.  ECONOMIC ASSUMPTIONS FOR STAND ANALYSIS
-------------------------------------------------------------------------------
                S
                P
          U     E                                          VALUE RATE CHANGES
          N     C                                                  AND
          I     I            LIMITS                             DURATIONS
          T     E       ----------------      CURRENT  ------------------------
  ITEM    S     S  DATE MIN DBH   VOLUME       VALUE   % FOR YEARS  % FOR YEARS
-------------------------------------------------------------------------------
NOTABLE2
DISCOUNT                                       6.00 % REAL
-------------------------------------------------------------------------------
**NOTE**  STAND = EXAMPLE    MANAGEMENT ID = RUN
```

Exhibit 7.—Table 1 output with sensitivity analysis.

TABLE 2- 0. UNDISCOUNTED CASH FLOW SUMMARY

ITEM			ACTUAL CASH FLOWS		CASH FLOW IF EXISTING STAND IS HARVESTED	
			COST	REVENUE	COST	REVENUE
MECHPREP COST	IN	1985	50.00			
PLANT COST	IN	1985	250.00			
ANNUAL COSTS	THRU	1985	2.60			
THINNING COSTS	IN	1985	.00		.00	
HARVEST COSTS	IN	1985	.00		.00	
HARVEST REVENUES	IN	1985		.00		.00
.SPECIAL COST	IN	1990	35.00			
ANNUAL COSTS	THRU	1995	26.00			
THINNING COSTS	IN	1995	.00		.00	
HARVEST COSTS	IN	1995	.00		.00	
HARVEST REVENUES	IN	1995		.00		.00
ANNUAL COSTS	THRU	2005	26.00			
THINNING COSTS	IN	2005	.00		.00	
HARVEST COSTS	IN	2005	.00		44.66	
HARVEST REVENUES	IN	2005		.00		99.99
ANNUAL COSTS	THRU	2015	26.00			
THINNING COSTS	IN	2015	.00		.00	
HARVEST COSTS	IN	2015	.00		419.84	
HARVEST REVENUES	IN	2015		.00		986.82
ANNUAL COSTS	THRU	2025	26.00			
THINNING COSTS	IN	2025	.00		.00	
HARVEST COSTS	IN	2025	.00		1141.58	
HARVEST REVENUES	IN	2025		.00		3434.91
ANNUAL COSTS	THRU	2035	26.00			
THINNING COSTS	IN	2035	.00		.00	
HARVEST COSTS	IN	2035	.00		2105.69	
HARVEST REVENUES	IN	2035		.00		7762.67
ANNUAL COSTS	THRU	2045	26.00			
THINNING COSTS	IN	2045	.00		.00	
HARVEST COSTS	IN	2045	.00		3212.96	
HARVEST REVENUES	IN	2045		.00		12881.04
ANNUAL COSTS	THRU	2055	26.00			
THINNING COSTS	IN	2055	.00		.00	
HARVEST COSTS	IN	2055	.00		4192.76	
HARVEST REVENUES	IN	2055		.00		17944.13
ANNUAL COSTS	THRU	2065	26.00			
THINNING COSTS	IN	2065	.00		.00	
HARVEST COSTS	IN	2065	.00		5042.41	
HARVEST REVENUES	IN	2065		.00		22014.85

Exhibit 8.—Table 2 output.

The column labeled ITEM is a listing of the management practices undertaken, whether it is a cost or revenue item, and the year (or years) in which the item occurred.

To understand the remaining columns, labeled ACTUAL CASH FLOWS and CASH FLOW IF EXISTING STAND IS HARVESTED, it is necessary to understand the general logic of CHEAPO II computations. CHEAPO II treats the end of each cycle as if it were the end of a rotation. Therefore, the first step CHEAPO II accomplishes is to determine the costs and revenues derived as if the existing stand were harvested. These are the values listed in the column CASH FLOW IF EXISTING STAND IS HARVESTED. Having completed this step, CHEAPO II next lists the cash flow associated with any treatments that were undertaken in the Prognosis Model projection. These are the

values listed in the column ACTUAL CASH FLOWS. The entire cash flow associated with this column is the actual cash flow of all treatments except those harvest treatments associated with the end of a potential rotation. That particular cash flow component is replaced by the IF EXISTING STAND IS HARVESTED cash flow component when CHEAPO II calculates the PNV, B/C Ratio, ROR, and SEV corresponding to that date. The analysis then proceeds to the next cycle.

Economic Analysis Summary: Table 3.—Economic analysis output displayed in output Table 3 consists of the analytical results presented on a cycle-by-cycle basis. The contents of this table depend on the analysis-type chosen. Exhibit 9 is an example of an analysis output Table 3 and the associated comment section for a simple present net value analysis.

The column labeled INVESTMENT YEAR is the same as the YEAR column shown earlier in output Table 2 (exhibit 8). It begins with the inventory year of the Prognosis Model projection and increments time according to subsequent cycle-ending dates.

The column labeled INVESTMENT AGE reflects the number of years that the costs and benefits are discounted to obtain present values. This also reflects the time increments along the investment time horizon. The investment time horizon always begins (investment year zero) with the inventory year of the Prognosis Model projection, unless otherwise specified for a soil expectation value analysis.

The columns labeled PRESENT VALUE, with subheadings of BENEFITS and COSTS, are the discounted value of the benefits and costs if the management regime was implemented up to, and the existing stand was harvested at the end of the cycle. The columns B/C RATIO, PRESENT NET VALUE, and % RATE OF RETURN contain the calculated values for the investment criteria.

TABLE 3- 0. ECONOMIC ANALYSIS SUMMARY FOR PNV ANALYSIS

INVESTMENT YEAR	INVESTMENT AGE	PRESENT VALUE BENEFITS	PRESENT VALUE COSTS	B/C RATIO	PRESENT NET VALUE	% RATE OF RETURN
1985	0	.00	302.60	.00	-302.60	---
1995	10	.00	352.46	.00	-352.46	< 0.0
2005	20	45.63	387.08	.12	-341.45	< 0.0
2015	30	304.25	505.77	.60	-201.52	1.2
2025	40	715.45	620.61	1.15	94.84	4.6
2035	50	1092.30	683.52	1.60	408.78	5.6
2045	60	1224.47	695.61	1.76	528.86	5.6
2055	70	1152.35	661.45	1.74	490.90	5.3
2065	80	955.09	612.31	1.56	342.78	4.8

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN
DISCOUNT RATE = 4.0% REAL

COMMENTS- 0. ECONOMIC ANALYSIS DOCUMENTATION

CHEAPOII USER'S GUIDE EXAMPLE

1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT COST FOR BRUSH CONTROL SPRAY
4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 9.—Table 3 output for a present net value analysis.

The benefit-cost ratio, present net value, and rate of return (unless the keyword NOROR is used to suppress printing rate of return results) are calculated and printed regardless of the analysis type selected.

Exhibit 10 is an example of an output Table 3 for a soil expectation value analysis. The table headings and interpretation of the table entries are the same as those shown earlier for the present net value analysis results (exhibit 9). The exception is that a column SOIL EXPECTATION VALUE is included. The soil expectation value results reflect the present net value of an infinite series of identical rotations for each cycle.

Exhibit 11 is an example of an output Table 3 for a present net value plus analysis. Again, the table headings and interpretation of the table entries are the same as shown earlier for present net value analysis results (exhibit 9). But the PNVPLUS analysis also includes a determination of the present net value of an infinite series of repeatable management regimes where the beginning and ending dates of the repeatable regime are user-specified. Therefore, at the bottom of output Table 3 for the PNVPLUS analysis, the results of this repeatable management are printed. The output includes the beginning and ending dates specified by the user and the analytical results.

TABLE 3- 0. ECONOMIC ANALYSIS SUMMARY FOR SEV ANALYSIS WITH BASE YEAR 1985

INVESTMENT YEAR	INVESTMENT AGE	PRESENT VALUE BENEFITS	PRESENT VALUE COSTS	B/C RATIO	PRESENT NET VALUE	% RATE OF RETURN	SOIL EXPECTATION VALUE
1985	0	.00	302.60	.00	-302.60	---	
1995	10	.00	352.46	.00	-352.46	< 0.0	-1080.95
2005	20	37.44	387.08	.10	-349.65	< 0.0	-641.01
2015	30	239.44	505.77	.47	-266.33	< 0.0	-383.89
2025	40	467.62	620.61	.75	-152.99	2.6	-192.55
2035	50	633.19	683.52	.93	-50.33	3.7	-58.15
2045	60	705.30	695.61	1.01	9.68	4.0	10.97
2055	70	646.93	661.45	.98	-14.52	4.0	-15.33
2065	80	541.08	612.31	.88	-71.23	3.7	-74.34

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN
DISCOUNT RATE = 4.0% REAL

Exhibit 10.—Table 3 output for a soil expectation value analysis.

TABLE 3- 0. ECONOMIC ANALYSIS SUMMARY FOR PNV PLUS ANALYSIS

INVESTMENT YEAR	INVESTMENT AGE	PRESENT VALUE BENEFITS	PRESENT VALUE COSTS	B/C RATIO	PRESENT NET VALUE	% RATE OF RETURN
1985	0	.00	302.60	.00	-302.60	---
1995	10	.00	352.46	.00	-352.46	< 0.0
2005	20	37.44	387.08	.10	-349.65	< 0.0
2015	30	239.44	505.77	.47	-266.33	< 0.0
2025	40	467.62	620.61	.75	-152.99	2.6
2035	50	633.19	683.52	.93	-50.33	3.7
2045	60	705.30	724.13	.97	-18.83	3.9
2055	70	705.30	726.13	.97	-20.84	3.9
2065	80	708.85	729.43	.97	-20.57	3.9
2075	90	728.06	740.71	.98	-12.65	4.0
2085	100	749.75	751.62	1.00	-1.88	4.0
2095	110	765.49	757.60	1.01	7.88	4.0
2105	120	772.34	758.75	1.02	13.59	4.0

THE PRESENT VALUE OF ALL ROTATIONS ASSUMING A REPEATABLE
MANAGEMENT REGIME FROM 2045 TO 2105 IS $ 14.00

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN
DISCOUNT RATE = 4.0% REAL

Exhibit 11.—Table 3 output for a present net value plus analysis.

Stand Summary Tables

The stand summary tables are optional output, requested by keywords. The keywords STDTABLE and ENDSTAND must be included in the CHEAPO II keyword input file to produce these output tables.

The first table printed (Stand Summary Table: All Species) is a summary for all of the species projected by the Prognosis Model (exhibit 12). The YEAR column is the same as the year columns in the economic analysis tables. It includes the inventory year and subsequent cycle-ending dates.

The STAND AGE column is the age of the stand as specified in the Prognosis Model.

Subsequent columns list the number of trees per acre, the cubic-foot volumes and board-foot volumes per acre, and the quadratic mean diameter of the stand at the end of each cycle. This information is provided for both the current stand and for any volume removed, as calculated by the Prognosis Model.

The remaining stand summary tables display the same data, but on an individual species basis as in exhibit 13 for western white pine, but with two additional changes. First, the volume printed is in the units specified on the analysis-type keyword record (BF or CF). Second, the volumes are reported in up to six diameter size classes. The diameter classes are those specified on the REVENUE keyword records. Similar tables also are provided if HARVCOST or THINCOST keywords are used. These tables show the distribution of trees or volume (depending on the unit of measure specified) for all species within the diameter classes defined by the HARVCOST and THINCOST keywords.

DISCUSSION

This user's guide to CHEAPO II describes the model's structure and behavior, options and features, and input requirements along with interpretation and control of output. Three points warrant mention:

1. This user's guide avoids discussing computer systems and job control language. These are location-specific topics. Depending on how CHEAPO II is installed at a given location, some of the features discussed in this user's guide may not be available. Users should check with computer system personnel regarding local procedures and limitations.

STAND SUMMARY TABLE : ALL SPECIES

		EXISTING STAND				REMOVALS			
YEAR	STAND AGE	TREES PER ACRE	CUBIC FOOT VOLUME	BOARD FOOT VOLUME	QUAD MEAN DBH	TREES PER ACRE	CUBIC FOOT VOLUME	BOARD FOOT VOLUME	QUAD MEAN DBH
1985	0	.0	.0	.0	.0	.0	.0	.0	.0
1995	10	600.0	.0	.0	1.3	.0	.0	.0	.0
2005	20	424.1	119.9	455.7	3.8	.0	.0	.0	.0
2015	30	379.0	1045.2	4284.1	6.3	.0	.0	.0	.0
2025	40	352.7	2680.3	11648.8	8.5	.0	.0	.0	.0
2035	50	313.8	4744.5	21486.6	10.4	.0	.0	.0	.0
2045	60	269.6	6918.8	32785.3	12.3	.0	.0	.0	.0
2055	70	226.9	8776.4	42783.3	14.0	.0	.0	.0	.0
2065	80	188.2	10352.3	51453.2	15.8	.0	.0	.0	.0

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 12.—Stand summary table—all species.

STAND SUMMARY TABLE : SPECIES WP

EXISTING STAND VOLUME (BD. FT.)

	STAND	DBH CLASS		
YEAR	AGE	7 TO 12	12 TO 15	15 +
1985	0	.00	.00	.00
1995	10	.00	.00	.00
2005	20	455.70	.00	.00
2015	30	3744.50	487.20	.00
2025	40	6337.40	3627.90	1372.60
2035	50	6902.90	6690.40	7277.40
2045	60	5783.50	7115.50	19040.70
2055	70	4375.70	7024.00	30455.80
2065	80	2857.00	5844.60	41837.70

REMOVAL VOLUME (BD. FT.)

	STAND	DBH CLASS		
YEAR	AGE	7 TO 12	12 TO 15	15 +
1985	0	.00	.00	.00
1995	10	.00	.00	.00
2005	20	.00	.00	.00
2015	30	.00	.00	.00
2025	40	.00	.00	.00
2035	50	.00	.00	.00
2045	60	.00	.00	.00
2055	70	.00	.00	.00
2065	80	.00	.00	.00

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 13.—Stand summary table—by species and diameter size class.

2. Because CHEAPO II is independent of the Prognosis Model, a given computer installation may have the most recent version of the Prognosis Model available, but only CHEAPO, not CHEAPO II. **The programs must be matched.** It is not possible to execute the old CHEAPO with data generated by the most recent version (5.1) of the Prognosis Model, nor will an old version of Prognosis Model generate a proper CHEAPO II file.

3. Although this guide is intended to allow users to successfully conduct CHEAPO II analyses, it is nevertheless quite elementary. Our experience has been that many more sophisticated and unusual analyses can be accomplished by the experienced user, by thoughtfully manipulating CHEAPO II instructions. We alluded to this when we discussed "tricking" CHEAPO II into performing the desired analyses. Expanded analytical capability of CHEAPO II will be more apparent with increased user familiarity and experience.

REFERENCES

Clutter, Jerome L.; Fortson, James C.; Pienaar, Leon V.; Brister, Graham H.; Bailey, Robert L. Timber management: a quantitative approach. New York: John Wiley and Sons; 1983. 333 p.

Davis, Kenneth P. Forest management: regulation and valuation. 2d ed. New York: McGraw; 1966. 519 p.

Duerr, William A. Fundamentals of forestry economics. New York: McGraw; 1960. 579 p.

Ferguson, Dennis E.; Crookston, Nicholas L. User's guide to the Regeneration Establishment Model—a Prognosis Model extension. General Technical Report INT-161. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984. 23 p.

Gregory, G. Robinson. Forest resource economics. New York: John Wiley and Sons; 1972. 548 p.

Gunter, John E.; Haney, Harry L., Jr. Essentials of forestry investment analysis. Corvallis, OR: O.S.U. Bookstores; 1984. 337 p.

Leuschner, William A. Introduction to forest resource management. New York: John Wiley and Sons; 1984. 298 p.

Medema, E. Lee; Hatch, Charles R. Computerized help for the economic analysis of prognosis-model outputs: a user's manual. Contribution No. 227. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station; 1982. 72 p.

Mills, Thomas J.; Dixon, Gary E. Ranking independent timber investments by alternative criteria. Research Paper PSW-166. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1982. 8 p.

Mishan, E. J. Cost-benefit analysis: an introduction. New York: Praeger Publishers; 1971. 364 p.

Monserud, Robert A.; Crookston, Nicholas L. A user's guide to the combined Stand Prognosis and Douglas-fir Tussock Moth Outbreak Model. General Technical Report INT-127. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 49 p.

Stage, Albert R. Prognosis Model for stand development. Research Paper INT-137. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 32 p.

Wippern, Ronald F. Capital expenditure analysis: a summary and overview. Unpublished manuscript copyrighted by the Harvard Business School; 1974. 19 p.

Wykoff, William R.; Crookston, Nicholas L.; Stage, Albert R. User's guide to the Stand Prognosis Model. General Technical Report INT-133. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 112 p.

APPENDIX A: KEYWORD REFERENCE

Type of keyword	Keyword	Page reference
Analysis-type	PNVANAL	11
	PNVPLUS	12
	SEVANAL	12
Economic assumption	ADMINIST	15
	BURNPREP	17
	CHEMICAL	17
	DISCOUNT	19
	FIXHCOST	15
	FIXTCOST	15
	FPROTECT	15
	HARVCOST	15
	MECHPREP	17
	NPV2	16
	NPV3	16
	OVERHEAD	15
	PLANT	17
	REVENUE	18
	SENSANAL	21
	SPCODES	38
	SPECCOST	16
	SPECREVN	18
	THINCOST	15
	THINSPEC	14
Program execution	ENDSTAND	21
	PROCESS	21
	REWIND	21
	STOP	22
Program output	COMMENT	23
	END	23
	NOROR	23
	NOTABLE1	22
	NOTABLE2	22
	NOTABLE3	22
	ROR	23
	STDTABLE	22
	TABLE1	22
	TABLE2	22
	TABLE3	22

APPENDIX B: SPECIES CODES

The species codes used in CHEAPO II are the same as those used in the Prognosis Model. The codes and species are as follows:

Common name	Scientific name	Default input code	Numeric code
Western white pine	*Pinus monticola*	WP	1
Western larch	*Larix occidentalis*	L	2
Douglas-fir	*Pseudotsuga menziesii*	DF	3
Grand fir	*Abies grandis*	GF	4
Western hemlock	*Tsuga heterophylla*	WH	5
Western redcedar	*Thuja plicata*	C	6
Lodgepole pine	*Pinus contorta*	LP	7
Engelmann spruce	*Picea engelmannii*	S	8
Subalpine fir	*Abies lasiocarpa*	AF	9
Ponderosa pine	*Pinus ponderosa*	PP	10
Other species	—	OT	11

Note: *Tsuga mertensiana* (mountain hemlock) is the species used to simulate the growth of all "other species." Numeric codes and letter codes with only one letter must be left-justified in the field.

The user has the option of changing the species codes listed prior to entering any REVENUE keyword records. Species codes are changed using SPCODES keyword records with corresponding supplemental records. Codes are entered left-justified in four column fields beginning in column 11 of the supplemental record. No continuation designation is required. When using SPCODES, **all** species codes must be entered as they will be used on REVENUE records. This is true for both altered and unaltered codes. For example, if the user wanted to change the western larch species code from L to WL, the necessary input records would be as follows:

```
                                      COLUMNS
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
========================================================================

SPCODES
          WP  WL  DF  GF  WH  C   LP  S   AF  PP  OT
              ↑
```


☆U.S. GOVERNMENT PRINTING OFFICE:1986— 676-039 / 41018

Horn, Joseph E.; Medema, E. Lee; Schuster, Ervin G. User's guide to CHEAPO II—economic analysis of Stand Prognosis Model outputs. General Technical Report INT-211. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 38 p.

CHEAPO II provides supplemental economic analysis capability for users of version 5.1 of the Stand Prognosis Model, including recent regeneration and insect outbreak extensions. Although patterned after the old CHEAPO model, CHEAPO II has more features and analytic capabilities, especially for analysis of existing and uneven-aged stands.

KEYWORDS: silviculture, economic analysis, timber management, investment analysis

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

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United States
Department of
Agriculture

Forest Service

**Intermountain
Research Station
Ogden, UT**

General Technical
Report INT-212

July 1986

Proceedings— National Wilderness Research Conference: Current Research

July 1986
Intermountain Research Station
324 25th Street
Ogden, UT 84401

FOREWORD

The National Wilderness Research Conference drew 400 people to Colorado State University in Fort Collins from July 23 to 26, 1985. The interest displayed by so many participants reflects the important values that wilderness has for Americans 21 years after passage of the Wilderness Act. In that time, the National Wilderness Preservation System has grown from 54 areas totalling 9 million acres to 445 areas and 89 million acres, and spread across the country, with a variety of settings, uses, and problems.

Which lands should be wilderness is still an important issue but it cannot be the only concern. Protecting and managing the areas classified as wilderness is essential, and the difficulty of this critical task has become more obvious. Management was the focus of the conference, the first ever to concentrate on wilderness research. "Learning to preserve" was the conference theme, highlighting the need for research knowledge to advance our ability to manage wilderness effectively so it will fulfill the goals established in the Wilderness Act.

The long list of conference sponsors reflects the recognition of the importance of wilderness, its management, and needed research. Sponsors were: U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service, and National Park Service; U.S. Department of Agriculture, Forest Service; American Wilderness Alliance; Colorado State University; and Oregon State University. Their support was essential to the conference's success.

Wilderness also involves esthetics and humanistic values that go beyond science and this side of wilderness was addressed by the 1985 Wilderness Art Exhibit, linked to the conference. Sixty very talented painters and sculptors displayed their works in a three-day show tied to the research presentations.

Wilderness is a composite of many elements and has numerous uses. Its management is complex and must deal with a wide range of problems. The research conference structure reflected this complexity and breadth.

There are two proceedings volumes. Another volume presents invited papers on wilderness values, management, research needs, and nine detailed state-of-knowledge reviews for major wilderness research topics. This volume includes over 70 reports of current wilderness research presented at the conference. These papers are organized around the same nine topics represented by the state-of-knowledge reviews: wilderness resource research, including natural fire, air quality, impacts to soil and vegetation, fish and wildlife, and water; and wilderness user research relating to recreational use and user characteristics, attitudes and behavior, benefits, and management concepts and tools.

It is encouraging to see how much wilderness research is being done, even while research budgets are becoming tighter. The quality of the research reported also makes me feel good. I have attended more conferences and symposia over the years than I care to count, but never have I heard such almost uniformly excellent papers based on solid research. With the concurrent paper format, I could only attend two sessions, but colleagues expressed similar good impressions from a number of sessions on other topics.

Each of the nine sessions was organized and conducted by a session coordinator who also arranged for all reviews of papers, and directed the referee process. These people, all prominent in research on their topic, agreed to handle this difficult task and I thank them many times over for their valuable and essential work. Each has written an introduction to the papers in their session, and many have suggested their views of needed research. The many people who conducted reviews also deserve thanks.

People planning future wilderness research should find these papers valuable for selecting problems to study and for developing research designs. We hope many scientists and students will continue to do first-class wilderness research, and that support for such research will grow; the Wilderness Research Foundation announced at the conference could make a much needed contribution to supporting future wilderness research.

Wilderness managers should find many of the results reported useful in formulating programs to protect wilderness resources and to provide high quality visitor experiences.

The conference was lots of work, lots of fun, and definitely worth it all. I am glad we did it, but it will be quite a while before I am ready to take on the job again! The original idea for the conference came from Glenn E. Haas, College of Forestry and Natural Resources, Colorado State University. Together with Glenn, Mike J. Manfredo, Department of Resource Recreation, Oregon State University; Sally A. Ranney, President, American Wilderness Alliance; and I were the planning committee. Colorado State

University and their Office of Conference Services hosted the conference well. The beauty of the setting, with the front range of the Rocky Mountains as a backdrop, probably helped inspire the participants as they enthusiastically grappled with wilderness research issues.

Special recognition is due Hollis Williford of Loveland, CO, who drew the cover illustration and generously donated it for use on the two proceedings volumes. The canoeists remind us of the time when most of the continent was wilderness. Hollis is also a director of the Wilderness Research Foundation, so he is doubly supportive of wilderness research. We thank him greatly.

We hope the major beneficiaries of the conference will be the wilderness resource and the people who will experience it far into the future.

ROBERT C. LUCAS
Proceedings Compiler

Proceedings—National Wilderness Research Conference: Current Research

Fort Collins, CO, July 23-26, 1985

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ROBERT C. LUCAS, Project Leader, Intermountain Research Station, Forest Service, U.S. Department of Agriculture

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Section 1. Wilderness Fire Research

AHEAD--COMPLEX AND DIFFICULT CHALLENGES

Mark H. Huff and James K. Agee
Session Coordinators

Disturbance plays a crucial role in ecosystem structure and function, whether that disturbance is glacial, volcanic, wind, insects and disease, or fire. In North America, fire has been without doubt the most common and widespread disturbance. Wilderness ecosystems, in particular, have evolved with fire, and in the common vernacular are "dependent" on it to maintain primeval conditions.

National policy shifts, summarized by Dr. Kilgore elsewhere in this proceedings, have been in place almost two decades. The questions about fire have shifted from those of "why" to those of "how": how to make decisions about natural fires, how to predict behavior, and how to predict and interpret fire effects in wilderness.

To understand the role of fire in wilderness and to manage the processes requires integration of social, economic, and biological disciplines. In the fire session, a broad range of fire topics is represented; these include: the effects of catastrophic fires on bird communities, response of vegetation to underburning in a forest that has been overprotected and consequently fire has been absent much longer than the natural fire regime, what we have learned over the years from one of the oldest and most successful natural fire management programs, methods to reduce the impacts of intensive fire research in wilderness, how to reintroduce and manage fire in different ecosystems under varying land management constraints and objectives, economic considerations of selecting a wilderness fire management plan, and how important managing fire in natural systems is to society.

Since wilderness ecosystems have evolved with fire, to perpetuate their inherent "naturalness" wilderness land managers must reconcile ways to ensure that fire remains part of the natural processes. This is an extremely difficult task, considering all the political, economic, and social constraints. Nonetheless, many of our wilderness ecosystems have been modified by past fire protection programs, and unfortunately will continue to be altered by some form of fire protection, except where the most liberal fire management plans are in effect.

To let all naturally occurring fires run their course in all wilderness areas is an impossible dream and might be quite inappropriate in wildernesses significantly altered by fire protection. Hence, what lies before us is a multitude of complex and difficult challenges for fire wilderness management. How we will proceed in answering the economic, social, and biological questions is the focus of our fire session.

Mark H. Huff is Postdoctoral Research Associate, College of Forest Resources, University of Washington, Seattle; James K. Agee is Research Biologist/Professor, National Park Service Cooperative Park Studies Unit, University of Washington, Seattle.

THE ROLE OF FIRE IN THE YOSEMITE WILDERNESS

Jan W. van Wagtendonk

ABSTRACT: Fire has played an important role in creating natural conditions in the Yosemite Wilderness. A computer analysis of historical lightning fires showed that fire occurrence and size varied significantly between different vegetation types, elevation zones, topographic positions, and drainage basins, and that fire size increased between 12-year periods before and after a wilderness fire management plan was implemented in 1972. This variation is attributed to differences in the nature of the fuel, lightning strike probabilities, and weather conditions favorable for fire spread. Information concerning the natural role of fire in wilderness has proven to be essential for informed fire management planning.

INTRODUCTION

The Wilderness Act (1964) specifies that areas in the National Wilderness Preservation System be "managed so as to preserve natural conditions." National Park Service (1978) policies state that "the preservation of wilderness character and values is the prime responsibility of the Service." The policies also recognize that lightning-caused fires are "natural phenomena which must be permitted to continue to influence the ecosystem if truly natural systems are to be perpetuated." A program using natural ignitions may only be initiated when an "analysis of past fire occurrence, distribution, control, and influence, indicates that natural vegetative accumulation and composition has not been significantly altered by past management of fire control."

Natural fire management zones were established in Sequoia and Kings Canyon National Parks in 1968 (Kilgore and Briggs 1972) and in Yosemite National Park in 1972 (van Wagtendonk 1978). These early programs were limited to high elevation forests where natural conditions had not been altered appreciably by past control activities (Bancroft and others 1985). In subsequent years, the zones were expanded based on analyses of historical fire occurrence and distribution patterns (Botti 1979; Vankat 1985; van Wagtendonk 1977) and fire scars (Kilgore and Taylor 1979).

The development of a computerized geographic information system for Yosemite provided an opportunity to reanalyze historical data to more definitively determine the role lightning fires have played in Yosemite's wilderness ecosystems. Specifically, it is hypothesized that fire occurrence and size varied significantly between different vegetation types, elevation zones, aspect classes, topographic positions, and drainage basins, and that fire size would increase between 12-year periods before and after the wilderness fire management program was initiated. This information is being used to refine the fire management planning process for the Yosemite Wilderness.

Yosemite National Park is located on the western slope of the central Sierra Nevada Mountains in California. The park consists of some 761,000 acres, 90 percent of which was designated wilderness in 1984. Elevations range from 2,000 feet on the western edge of the park to over 13,000 feet at the crest (fig. 1). Two major river canyons, the Merced and the Tuolumne, incise the park from east to west. Side drainages generally run north or south into both rivers.

Figure 1.--Physiography of Yosemite National Park.

Paper presented at the National Wilderness Research Conference, Fort Collins, CO, July 23-26, 1985.

Jan W. van Wagtendonk is Research Scientist, National Park Service, Yosemite National Park, El Portal, CA.

Yosemite has a Mediterranean type climate with hot, dry summers and cold, moist winters (Elford 1970). Temperatures range from a mean minimum of 12 °F during January at the high elevations to a mean maximum of 90 °F in July at the lower elevations. Normal annual precipitation also varies with elevation from 32 inches at the western boundary to a maximum of 48 inches at the mid elevations. At the highest elevations, normal annual precipitation is reduced to 24 inches because these areas extend above the level of maximum transport of the moisture laden winds from the Pacific. The precipitation occurs primarily from November through March as winter storms move through, depositing snow over much of the park. Lightning storms may occur at any time of the year throughout the park, but are concentrated during the summer months and at the higher elevations. These storms generally travel from south and southwest to north and northeast (Komarek 1967).

The vegetation responds to climate and topography with chaparral woodlands on the steep canyon walls, conifer forests covering the mid elevations, and alpine meadows above timberline (fig. 2). The chaparral woodlands consist of manzanita (Artostaphylos viscida, A. mariposa), ceanothus (Ceanothus intergerrimus, C. cuneatus), and mountain mahogany (Cercocarpus betuloides) underneath stands of live oaks (Quercus chrysolepsis, Q. wislizenii) and digger pine (Pinus sabiniana).

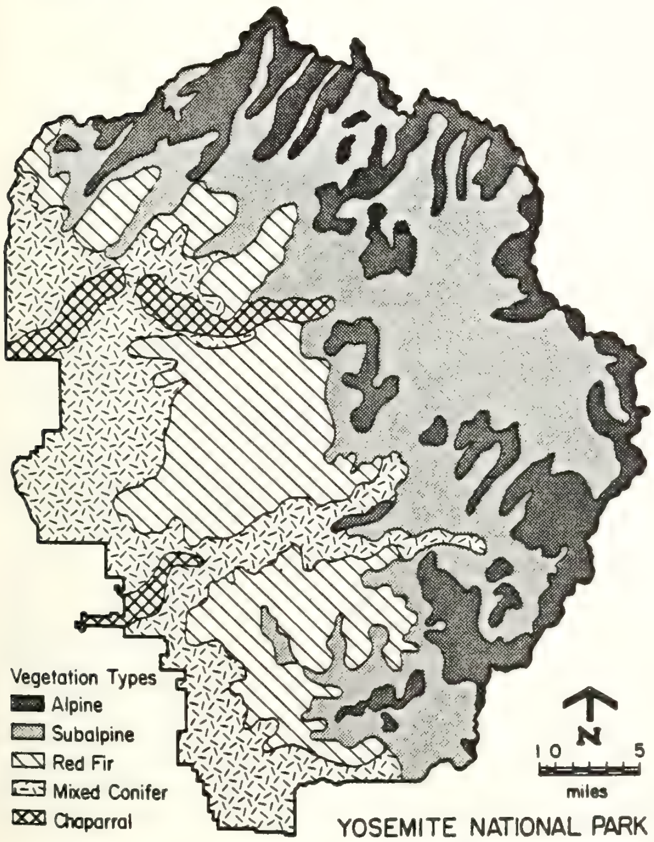

Figure 2.--Vegetation zones of Yosemite National Park.

The mid-elevation forests include a broad range of conifer species with ponderosa pine (Pinus ponderosa) the dominant at the lower end of the zone. As elevation increases, incense-cedar (Calocedrus decurrens), Douglas-fir (Pseudotsuga menziesii), sugar pine (P. lambertiana), and white fir (Abies concolor) are added to the mixed conifers. Giant sequoias (Sequoiadendron giganteum) occur in three isolated groves in the upper mixed conifer forests. These species give way to red fir (A. magnifica) around 7,500 feet with Jeffrey pine (P. jeffreyi), western white pine (P. monticola), and western juniper (Juniperus occidentalis) occupying exposed ridges. Above the red fir forests, lodgepole pine (P. contorta) dominates with mountain hemlock (Tsuga mertensiana) occurring on north facing slopes. These two species are found at timberline (10,500 - 11,000 feet) although whitebark pine (P. albicaulis) is dominant at that elevation. The conifer forests are interspersed with meadows and stands of montane chaparral including manzanita (A. patula), ceanothus (C. cordulatus), and huckleberry oak (Q. vaccinifolia). Above timberline, alpine meadows and willow (Salix sp.) shrubs are found among large expanses of barren rock.

METHODOLOGY

Fire records dating back to 1930 are kept on file in the park. These were reviewed and the point of ignition and areal extent of each fire were plotted on topographic maps along with the date and fire number. The quality of the information in the records varied from year to year. Sometimes only a rough description of the location of the fire was recorded and at other times very complete information was available. Knowledge of topography, vegetation, and fire burning patterns was used to identify specific locations when information was lacking. Fire locations and UTM ticks were then transferred to stable mylar sheets overlaid on mylar base maps and digitized by the Service's Geographic Information System Field Unit in Denver. The SAGIS software was used for this process (Bartholow 1982).

Vegetation types were taken from maps compiled during the 1930's from field surveys and sample plots (Coffman 1934). Over 1,200 different combinations of species were classified into 18 vegetation types before being transferred to mylar sheets and digitized for input to SAGIS. Vegetation information from the Thematic Mapper on LANDSAT-5 is currently being classified using ELAS software (Graham and others 1985). The new information will replace the older type map as soon as it is available.

Topographic data were obtained from the Defense Mapping Agency (DMA) and manipulated using ELAS. Eleven elevation zones (1,000 foot bands), and nine aspect classes (flat, north, northeast, east, southeast, south, southwest, west and northwest), were derived from the DMA data. The completed data sets were then transferred to the

SAGIS software for analysis. SAGIS cannot analyze topographic position at the present time.

Two additional themes were digitized by hand and put up on SAGIS. These were drainage basins (40) and fire management zones (5). SAGIS operations "overlay" and "matrix" were used to make comparisons for fire occurrence and size between vegetation types, elevation zones, aspect classes, drainage basins, and management periods. Chi-square analyses were used to determine if these comparisons were random. All tests of significance were at the 0.05 level.

FINDINGS

For the 54-year period from 1930 through 1983, 2,023 lightning fires were recorded in Yosemite. The average number of fires per year was 37.5, with a range from one fire in 1954 to 121 fires in 1967 (fig. 3). Expressed in terms of area, the average would be 49.2 fires per million acres per year (Bevins and Barney 1980). Actual lightning ignitions were probably higher especially during the 1930's and 1940's when detection methods were less sophisticated (Botti 1979). During those two decades, the average number of fires per year was 15.6 while the average for the subsequent 34 years was 50.4 fires. Vankat (1985) attributed a similar disparity to the advent of aerial detection methods in the late 1960's. He also speculated that changes in vegetation might have contributed to the increase in ignitions.

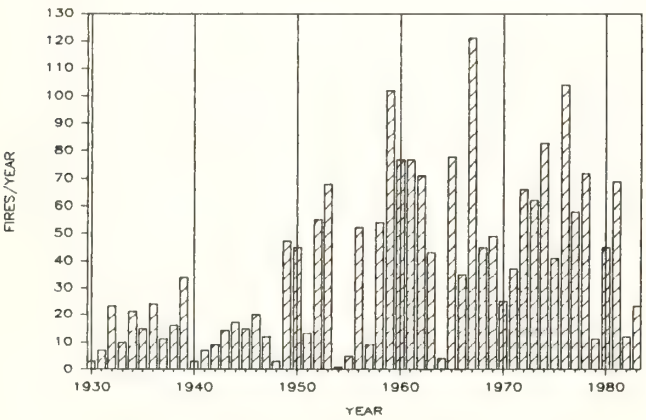

Figure 3.--Annual lightning fire occurrence, Yosemite National Park, 1930-1983.

Although monthly distributions were not calculated in this study, Botti (1979) found that 81 percent of the lightning fires in Yosemite between 1930 and 1975 occurred during July, August, and September. This compares to 85 percent for the same months in Sequoia National Park for the period from 1921 through 1982 (Vankat 1985).

Drainage Basin

As can be seen from figure 4, most lightning fires have occurred in the western two-thirds of the park. This corresponds to the low- to mid-elevations and excludes the barren mountain crests. The number of fires in drainage basins throughout the western portion of the park varied from 151.7 to 88.6 per million acres per year. Drainage basins in the middle third of the park had fire occurrences ranging from 86.4 to 52.7 fires per million acres per year. Much lower numbers of fires (37.1 to 1.0) were recorded for the higher elevation eastern third. Large fires occurred primarily in basins at the mid-elevations. In particular the Illilouette Creek and Frog Creek drainages had average fire sizes of 27.7 and 37.5 acres per fire, respectively. The average for all other drainages was 14.2 acres.

Figure 4.--Lightning fire occurrence, Yosemite National Park, 1930-1983. Crosses are fires less than 10 acres in size. Larger fires are represented by their perimeters.

Elevation Zone

Lightning fires occurred from 3,500 feet in the Merced Canyon to 12,000 feet on the Sierra crest. The percent of fires occurring in elevation zones was significantly different from the percent of area in the zones. The greatest proportion (73.1 percent) of lightning fires was ignited at the mid elevations, from 5,000 to 8,000 feet (fig. 5). That same elevation range accounted for only 39.7 percent of the area.

Although there are abundant fuels and extreme burning conditions at lower elevations, the land base is small (6.9 percent) and lightning strikes

infrequent. On the other hand, elevations above 8,000 feet account for 53.4 percent of the area but only 20.2 percent of the fires. There lightning is common during summer but burning and fuel conditions are insufficient. A similar pattern occurred in Sequoia National Park, although the mean fire elevation was about 1,000 feet higher since the park is 85 miles farther south (Vankat 1985).

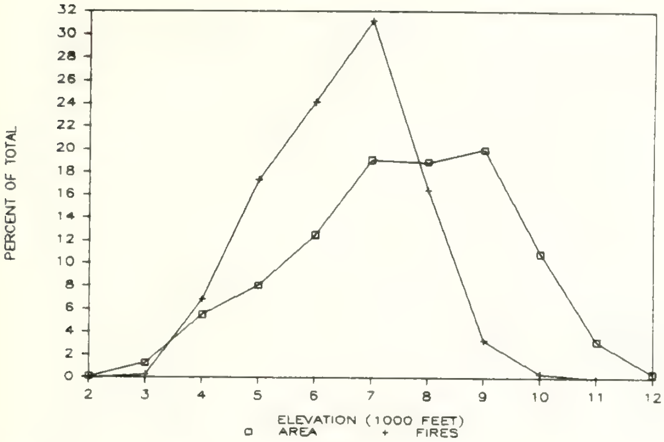

Figure 5.--Percent lightning fires and percent area occurring in 1,000-foot elevation zones, Yosemite National Park, 1930-1983.

Fire size is dependent on burning conditions, fuels, topography, time of ignition, and, prior to 1972, the suppression effort. It can be assumed, however, that large suppressed fires would have been proportionally larger if allowed to burn. As can be seen from figure 4, the largest fires occurred in the mid-elevational zone between 7,000 and 8,000 feet. While these occasional large fires exceeded fire sizes at other elevations, a greater number of fires in the 3,000- to 4,000-foot zone reached a moderate size.

Aspect Class

Lightning fire ignitions did not vary significantly by aspect. The greatest preponderance of fires, however, occurred on northwest-facing slopes, comprising 16.2 percent of the total (fig. 6). West-facing slopes were next with 15.4 percent and north- and east-facing slopes had the least with 7.8 percent each. The park is predominantly west-facing with those slopes constituting nearly one-half of the exposures. Komarek (1967) found similar results for national forests in California, as did Vankat (1985) in Sequoia National Park. Kilgore and Taylor (1979) examined fire scars in adjacent Kings Canyon National Park and concluded that fire was more frequent in southwest- than on southeast-facing slopes.

Aspect did affect fire size. Sixty-seven percent of the fires larger than 50 acres occurred on west-facing slopes. South-facing slopes accounted for 22 percent of those fires, east-facing slopes had 11 percent and north-facing slopes had none. Hotter and drier conditions on west and south slopes explain these differences.

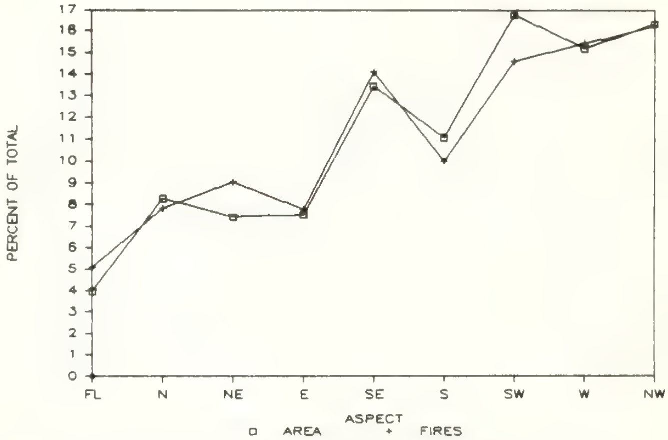

Figure 6.--Percent lightning fires and percent area occurring in nine aspect classes, Yosemite National Park, 1930-1983.

Topographic Position

The software packages used for this analysis are currently unable to delineate topographic position, although that capability is expected soon. Botti (1979), however, found that ridge tops accounted for 30 percent of the lightning fires, ravines and valley bottoms 12 percent, and intervening slopes 58 percent. Komarek (1967) reported values for California national forests in 1966 of 15, 14, and 71 percent for ridge tops, slopes, and valleys, respectively. The percents for the same topographic positions in Sequoia National Park were 29, 8, and 63 (Vankat 1985). In Yosemite, 47 percent of the fires larger than 50 acres occurred on ridge tops. The intervening slopes accounted for 47 percent while ravines and valleys had only 6 percent.

Vegetation Type

Vegetation is largely an expression of climate as influenced by topography. Fires are also affected by weather and topography, as well as the fuel produced by the vegetation. Weather conditions and fuel characteristics at locations of lightning strikes determine fire occurrence. Fire size is influenced by weather subsequent to ignition and the slopes and fuels lying ahead of the fire. Fire occurrence and size differences between vegetation types are caused by differences in these factors (table 1).

Chaparral woodlands cover approximately 4.2 percent of the park and 1.9 percent of the fires occur there. The chaparral species in this community are adapted to a regime of intense fires every 20 to 30 years (Parsons 1976).

Vigorous sprouting or germination from scarified seeds are the primary means of reproduction after fire. The live oaks in this type are also sprouters and digger pines easily reestablish in burned areas. Without fire chaparral stands become senescent and die out. For the first few years after a fire chaparral stands seldom reburn because the proportion of live fuels is high. This results in a mosaic of age classes which, combined with topography, prevented any single fire from becoming too large. The average size for fires larger than 10 acres in chaparral has been 177.5 acres. Although weather conditions are extreme every year in this type, infrequent lightning strikes cause occurrence to be lower than for the mid-elevation conifer types. The average number of fires per year on a million acre basis has been 22.0. When an ignition does occur, however, the fire is very intense.

Table 1.--Distribution of lightning fires by vegetation type. Yosemite National Park, 1930-1983

Vegetation Type	Area		Lightning Fires		
	acres	%	No.	%	#/m/y
Chaparral woodland	31,975	4.2	38	1.9	22.0
Lower mixed conifer	146,935	19.3	563	27.8	71.0
Upper mixed conifer	108,869	14.3	513	25.3	87.3
Red fir	63,951	8.4	327	16.2	94.7
Lodgepole pine	232,202	30.5	467	23.1	37.2
Subalpine	59,383	7.8	36	1.8	11.2
Alpine	110,391	14.5	73	3.6	12.2
Misc.	7,613	1.0	6	.3	14.6
Total	761,319	100.0	2,023	100.0	49.2

The lower mixed conifer zone, where ponderosa pine dominates, includes 19.3 percent of the park and receives 27.8 percent of the lightning ignitions. The average annual number has been 71.0 fires per million acres. Although highly flammable fuel is produced annually by the pines, the probability of simultaneous occurrence of lightning, burning conditions, and adequate fuel produces a fire-free period of 8 to 10 years (Kilgore and Taylor 1979; van Wagtendonk 1985; Wagener 1961). These fires are generally surface fires of low intensity and those larger than 10 acres cover an average of 138.5 acres. Fuel moisture differences caused by topography and fuel bed changes limit fire size. These fires favor fire-tolerant species such as ponderosa pine over fire-intolerant incense-cedar and white fir (van Wagtendonk 1983). Without natural fires, fuels would quickly accumulate and a species shift to incense-cedar and white fir would occur.

White fir is the dominant species in the upper mixed conifer forest which constitutes 14.3 percent of the park. Lightning strikes are more frequent there and result in 25.4 percent of the fires, averaging 87.3 fires per year per million acres. These fires usually occur in late summer or early fall when the relatively compact fuel beds finally dry out from the heavy snow pack. The fires are generally slow moving except in areas where pine fuels or montane chaparral are present. There locally intense fires can occur during severe fire weather conditions resulting in extremely large fires.

Maximum fire size is controlled by fire duration although spatial distribution of ages of burns appears to also limit size. This has been illustrated by a series of fires that burned in the Illilouette drainage after the wilderness fire management plan was put into effect (fig. 7). In 1974, the Starr King fire burned 3,500 acres east of Illilouette Creek (van Wagtendonk 1978). Four years later the 550-acre Hoover fire and the 320-acre J. L. fire burned to within one mile of the Starr King fire before they went out. The forward progress of the 1,500-acre Illilouette fire in 1980 was stopped when it burned against the previous fires with some low intensity reburning of the Starr King fire area. In 1982, a fourth fire, the 2,219-acre Buena Vista fire burned out along a 1.5 mile front with the Illilouette fire, but did reburn about 80 acres of the Starr King fire. This jigsaw puzzle of burning patterns appears to prevent any one fire from becoming much larger than 5,000 to 10,000 acres.

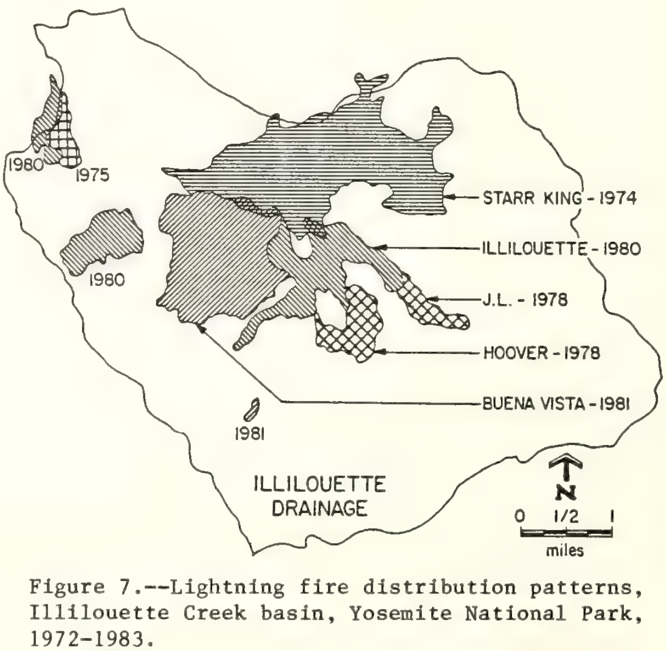

Figure 7.--Lightning fire distribution patterns, Illilouette Creek basin, Yosemite National Park, 1972-1983.

Fire suppression efforts have had less ecological effect in the upper mixed conifer type than in the lower mixed type. More compact fuels and slightly cooler weather result in a fire-free interval of around 15 years. Species shifts have been less dramatic since white fir is already dominant although natural fuel accumulation is higher than in any other type.

Although red fir covers only 8.4 percent of the park and is not considered a fire species, 16.2 percent of the fires occur in this type. On a million acre basis, the annual average of 94.7 fires is the highest of all vegetation types. Most of these fires are single trees struck by lightning although occasional large fires burn through stands mixed with montane chaparral. Botti (1979) attributes the presence of large stands of pure red fir to the absence of large intense fires in the past. Openings that are created in these stands become established with lodgepole pine. Fire-free interval estimates for this type have not been made although it seems probable that they are greater than 50 to 100 years (Kilgore 1981).

The lodgepole pine forest is the most extensive type in Yosemite, covering 30.5 percent of the park, while only 23.1 percent of the lightning fires occur there. The annual average for this type is 37.2 fires per million acres. Lightning strikes from summer storms are frequent but fuels are sparse and rain often accompanies the strike. When an ignition does occur, fire spreads slowly along logs in a zig-zag pattern (Gara and others 1984). Intervening areas are open and often covered with green herbaceous vegetation. Fire size is rarely over one acre although three fires have exceeded 10 acres.

The subalpine zone occupies 7.8 percent of the park and accounts for only 1.8 percent of the fires (11.2 fires/million acres/year). Most areas never burn although some intense fires have been observed in dwarfed whitebark pine stands at 10,500 feet (Botti 1979). No fires have exceeded 10 acres in size. The alpine zone is nearly twice as large (14.5 percent) and twice as many (3.6 percent) fires burned there. Most of those were isolated trees in barren areas. The million acre annual average is 12.2 fires.

The pattern of occurrence and size of lightning fires in vegetation types is similar for California national forests (Komarek 1967) and for Sequoia National Park (Vankat 1985). The California data were for 1966 and showed a preponderance (37.8 percent) of fires in the upper mixed conifer zone. That zone also had the greatest percent of fires (35 percent) in Sequoia National Park. Yearly and geographic variation could account for these differences.

Management Period

During the 12-year period before the wilderness fire management program was implemented, 674 lightning ignitions occurred in the park. Of these, 260 were in the area currently included in the wilderness fire zone. Out of the 633 fires igniting during the subsequent 12-year period throughout the park, 419 were suppressed. The remaining 214 were inside the wilderness fire zone and were allowed to burn. These fires are compared in table 2 to the 260 suppressed fires during the previous 12 years. Only the 1,484-acre Mt. Gibson fire, which burned in 1960, reached the same proportions as have been common for recent large wilderness fires. That fire burned extensive stands of montane chaparral, an important factor in its spread (Botti 1979). More striking is the lack of fires in the 300- to 999-acre size class prior to 1972. Eleven fires in that class have burned since then, mostly in the lower mixed conifer type. Suppression efforts have been more successful in that type because of access. Fuel build up poses a potential problem if these areas are added to a wilderness fire program. Prescribed burning has been an initial step in Yosemite to deal with these unnatural fuel accumulations.

Table 2.--Distribution of lightning fires by size class in 12-year periods before and after implementation of a wilderness fire management program, Yosemite National Park

Size Class	Time Period			
	1960 - 1971		1972 - 1983	
acres	No.	%	No.	%
0 - 9.9	253	97.3	171	79.9
10 - 49.9	5	1.9	12	5.6
50 - 299	1	0.4	15	7.0
300 - 999	0	0.0	11	5.1
1000+	1	0.4	5	2.4
Total	260	100.0	214	100.0

MANAGEMENT AND RESEARCH IMPLICATIONS

Fischer (1984) stresses the importance of gathering information on the role of fire as part of the process of developing a wilderness fire management plan. A geographic information system provides an excellent means for compiling fire history data and analyzing these data for ecological relationships.

In order to allow fire to achieve its natural role in wilderness, management plans must assess the change that has occurred as a result of past suppression activities. In vegetation types with short intervals between fires, this change can be dramatic (van Wagtendonk 1985). Information from the assessment can then be used to develop fire management objectives. For

instance, in Yosemite, it was determined that unnatural fuel accumulations and species composition shifts had been significant and that steps had to be taken to correct those adverse effects.

Prescribed burning programs were initiated to reduce fuels and restore species composition. The number of burns necessary to accomplish these objectives was based on the natural fire regime (van Wagtendonk 1985). Although these burns were conducted prior to designation as wilderness, they will continue within the wilderness until the unnatural buildup of fuels is reduced.

The Wilderness Act (1964) specifically states that "... measures may be taken as may be necessary in the control of fire..." The House Report (HR 98-40) that accompanied the California Wilderness Act (1984) elaborated this point by stating that "... prescribed burning could prove to be an especially significant fire presuppression method, especially where a history of past fire suppression policies have allowed "unnatural" accumulations of dead or live fuels (such as chaparral) to build up to hazardous levels." This means that even though there is no immediate threat of wildfire, fuels "... in excess of that which 'might' have existed had fire been allowed to burn naturally," could be prescribed burned (Hildner 1985). The program in Yosemite is consistent with the intent of Congress and is based on sound knowledge of the role of fire in wilderness ecosystems.

In addition to fire planning, the Geographic Information System has other applications to wilderness management. Spatial data on fuels can be combined with topography and current weather to predict the behavior of ongoing lightning fires. Managers could use these predictions to see if heavily used areas need to be evacuated or trails closed before a potential problem occurs. Maps of current fires would also be useful for visitors to plan their trips to avoid burned areas or to observe fire in its natural role. The information gained from the computerized information system will continue to guide management actions and contribute to scientific understanding.

ACKNOWLEDGMENTS

Walter Sydoriak deserves full credit for compiling the data themes, transferring them to mylar sheets, and drawing the figures. The Park Service's Geographic Information Systems Field Unit in Denver provided the vegetation and topography data, digitized and encoded the fire history and management zone data, and performed the analyses. Particular recognition should go to Harvy Fleet, Maury Nyquist, Ralph Root, Sharon Shin, Susan Stitt, and Nancy Thorwaldson.

REFERENCES

Bancroft, Larry; Nichols, Thomas; Parsons, David; Graber, David; Evison, Boyd; van Wagtendonk, Jan. Evolution of the fire management program at Sequoia and Kings Canyon National Parks. In: Lotan, James E.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., technical coordinators. Proceedings - symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. General Technical Report INT-182. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 174-180.

Bartholow, J. SAGIS utilities user's manual. Fort Collins, CO: U.S. Department of Interior, U.S. Fish and Wildlife Service, Western Energy and Land Use Team; 1982. 220 p.

Bevins, Collin D.; Barney, Richard J. Lightning fire densities and their management implications on Northern Region national forests. In: Proceedings 6th conference on fire and forest meteorology; 1980 April 22-24; Seattle, WA. Washington DC: Society of American Foresters; 1980: 127-131.

Botti, Stephen J. Natural, conditional, and prescribed fire management plan. Yosemite National Park, CA: U.S. Department of Interior, National Park Service, Yosemite National Park; 1979. 51 p.

California Wilderness Act of 1984. Act of August 7, 1984. Public Law 98-425, as amended.

Coffman, J. D. Suggestions for the mapping and study of vegetative cover types in areas administered by the National Park Service. Washington DC: U.S. Department of Interior, National Park Service, Branch of Forestry; 1934. 27 p.

Elford, C. Robert. Climate of California. Climatography of the United States No. 60-4. Silver Springs, MD: U.S. Department of Commerce, Environmental Science Services Administration, Environmental Data Service; 1970. 57 p.

Fischer, William C. Wilderness fire management planning guide. General Technical Report INT-171. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984. 56 p.

Gara, R. I.; Littke, W. R.; Agee, J. K.; Geiszler, D. R.; Stuart, J. D.; Driver, C. H. Influence of fires, fungi, and mountain pine beetle on development of a lodgepole pine forest in south-central Oregon. In: Proceedings, Lodgepole pine symposium. 1984 May 8-10; Spokane, WA. Pullman, WA: Washington State University; 1984. 153-162.

Graham, M. H.; Junkin, B. G.; Kalsic, M. T.; Pearson, R. W.; Seyfrath, B. R. ELAS-Earth Resources Laboratory applications software. Report No. 183. NSTL Station, MS: National Aeronautics and Space Administration, National Space Technology Laboratories; 1985. 1 vol.

Hildner, Richard. In wilderness areas, fire is not a four-letter word. [Paonia, CO] High Country News. 1985 May 27: 16(col. 1).

House of Representatives. Report together with minority and supplemental views. Report No. 98-40. Washington D.C.: House of Representatives; 1983. 57 p.

Kilgore, Bruce M. Fire in ecosystem distribution and structure: western forests and scrublands. In: Mooney, H. A.; Bonnickson, T. M.; Christensen, N. L.; Lotan, J. E.; Reiners, W. A., technical coordinators. Proceedings of the conference: Fire regimes and ecosystem properties; 1978 December 11-15; Honolulu, HI. General Technical Report WO-26. Washington D.C.: U.S. Department of Agriculture, Forest Service; 1981: 58-89.

Kilgore, Bruce M.; Briggs, George S. Restoring fire to high elevation forests in California. Journal of Forestry. 70(5): 266-271; 1972.

Kilgore, Bruce M.; Taylor, Dan. Fire history of a Sequoia-mixed conifer forest. Ecology. 60(1): 129-142; 1979.

Komarek, E. V., Sr. The nature of lightning fires. In: Proceedings California Tall Timbers Fire Ecology Conference No. 7; 1967 November 9-10; Hoberg, CA. Tallahassee, FL: Tall Timbers Research Station; 1967: 5-41.

National Park Service. Management policies. Washington D.C.: U.S. Department of Interior, National Park Service; 1978. 1 vol.

Parsons, David J. The role of fire in natural communities: an example from the southern Sierra Nevada, California. Environmental Conservation. 3(2): 91-99; 1976.

Vankat, John L. General patterns of lightning ignitions in Sequoia National Park, California. In: Lotan, James E.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., technical coordinators. Proceedings - symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. General Technical Report INT-182. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 408-411.

van Wagtendonk, Jan W. Fire management in the Yosemite mixed-conifer ecosystem. In: Mooney, Harold A.; Conrad, C. Eugene, technical coordinators. Proceedings of the symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems; 1977 August 1-5; Palo Alto, CA. General Technical Report WO-3. Washington D.C.: U.S. Department of Agriculture, Forest Service; 1977: 459-463.

van Wagtendonk, Jan W. Wilderness fire management in Yosemite National Park. In: Schofield, Edmund A., editor. EARTHCARE: Global protection of natural areas, proceedings of the 14th biennial wilderness conference; 1975 June 5-8; New York. Boulder, CO: Westview Press; 1978: 324-335.

van Wagtendonk, Jan W. Prescribed fire effects on forest understory mortality. In: Preprint, 7th Conference, Fire and Forest Meteorology; 1983 April 25-28; Fort Collins, CO. Boston, MA: American Meteorological Society; 1983: 136-138.

van Wagtendonk, Jan W. Fire suppression effects on fuels and succession in short-fire-interval wilderness ecosystems. In: Lotan, James E.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., technical coordinators. Proceedings - symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. General Technical Report INT-82. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 119-126.

Wagener, Willis W. Past fire incidence in Sierra Nevada forests. Journal of Forestry. 59(5): 739-748; 1961.

Wilderness Act. Act of September 3, 1964. Public Law 88-577, as amended.

CHANGES IN BIRD POPULATIONS DURING SUCCESSION FOLLOWING FIRE IN THE NORTHERN GREAT LAKES WILDERNESS

Steven I. Apfelbaum and Alan Haney

ABSTRACT: Sixteen upland communities, representing 370 years of succession following wildfire in the Boundary Waters Canoe Area Wilderness of Superior National Forest and contiguous Quetico Provincial Park of Ontario were inventoried from 1976 through 1985. Using 15.4 acre grids, all resident bird territories were plotted in each community and transient and peripheral species were recorded. By comparing bird populations, we identified four community types. Early communities, the first 23 years after fire, had as high bird diversity but half the bird density as mature communities that developed 100 to 200 years after fire. Intermediate communities developed within 50 years as jack pine and aspen canopies matured and had a third less species, but comparable bird density as early communities. Oldgrowth communities, 300 or more years after fire, had lower diversity and density than mature communties with more internal variance of bird density, indicating disruption of community structure. We believe that species and communities in this region have adapted to fire and that in the long-term absence of fire, communities begin to fragment. Fire suppression will likely result in unforseen changes in populations and community structures.

INTRODUCTION

Wilderness areas, such as parts of Boundary Waters Canoe Area Wilderness and Quetico Provincial Park, offer opportunities to examine community structure during succession influenced, primarily, by natural forces. Fire has been a natural perturbation initiating succession in the northern Great Lakes forests for many centuries, and probably much longer (Maissurow 1941; Heinselman 1973).

Most studies of secondary succession have examined changes in fallowed fields. Forest succession after fire is different than succession after agriculture; often fallow agriculture fields are islands in a mosaic of communities where species invasion is proportional to the degree of temporal and spatial isolation. Moreover, the early vegetation of fallowed agriculture fields includes many non-native species in less natural associations. The diversity and structural patterns, therefore, may differ from those patterns found in wilderness.

We (Apfelbaum and Haney 1981) and Niemi (1978) have studied short-term response of birds following fire in the Boundary Waters. Several studies have examined trends in bird populations during succession within a sere (Smith and MacMahon 1980; Austin and Perry 1979; Meslow and Wight 1975; Kricher 1973; Haapanen 1965; Johnston and Odum 1956; Odum 1950) or during succession after fire (Bock and others 1978; Taylor and Barmore 1980; Taylor 1973), but we are aware of no studies, that have examined bird succession within a fire sere from immediate post-fire to oldgrowth communities.

We examined relationships of wildfire to vegetation and bird communities in the Great Lakes Pine Transitional forests. Fifteen upland communities, from one to 370 years old were chosen to represent a successional series (sere) following wildfire in the Boundary Waters Canoe Area Wilderness of Superior National Forest, Minnesota, and adjacent Quetico Provincial Park, Ontario (L.50° N., L. 91° 30'W.). Vegetation and avian populations were sampled from late May through late June, from 1976 through 1984.

METHODS

We selected study sites in upland communities that burned 1, 2, 3, 3, 7, 15, 23, 67, 73, 112, 175, 176, 366, 367, and 370 years before our fieldwork was initiated. Ages of the communities were largely determined from stand origin maps prepared for parts of Superior National Forest and Quetico Provincial Park by Miron Heinselman and Robert Day (Heinselman 1976, pers. commun.), respectively. Ages were verified in the field by coring 2 to 5 dominant trees. In addition, we studied the effects of wind where dominant trees had been leveled by wind five years previously; this blowdown community was adjacent to and between the 175 and 366 year-old communities.

Grids, 273.25 x 273.25 yd. (250 x 250 m), internally flagged at 54.65 yd. (50 m) intervals, were placed in representative portions of each study site. These 15.4 acre (6.25 ha) grids included exposed rock, small bogs, and frequent draws with

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colluvial or till mineral substrates. Methods of sampling birds and vegetation, and data analysis used by Apfelbaum and Haney (1981) are summarized here.

At each study site, birds were censused over several consecutive days from dawn to mid-morning, 3-5 hours per census. For mapping bird territories, we employed spot-map (Williams 1936) and flush-plot (Kendeigh 1944) techniques. Each census was taken by both authors, slowly walking grid lines, and plotting locations of each bird heard or seen. Bird locations and movements were recorded on scaled grid sheets, compiled on summary grids and used to estimate territories. Censuses were continued until territories became defined; requiring 20 man-hours in the least complex community, and over 50 hours in more diverse communities. Communities censused in late May or early June were recensused in mid or late June to ensure that territories were not influenced by late migrants.

Richness, number of individuals, and relative density of each species were determined for each community. Frequency, the percent of grid sections in which a species was found, was determined, and relative frequency for each species was calculated. Relative territory cover, the total area within each 15.4 acre study site occupied by the combined territories of each species, was calculated.

Numbers of individuals of each species (density), area of the community they occupied (cover), and distribution within a community (frequency) does not address the total resource use of a species. We, therefore, calculated existence energy (Kendeigh 1970), the energy required for an average individual of a species to maintain itself in a 24 hour period, exclusive of reproduction, to provide a more comprehensive basis for comparing species (Apfelbaum and Haney 1981). A composite index was derived by the sum of relative cover, frequency, and existence energy. This importance value, an abstract number scaled from 0-300, was used to compare guilds (Apfelbaum and Haney 1981) and species (Curtis 1959) in each community. Guild designations of Bock and Lynch (1970) were used.

We report diversity (H', base 10) for information on richness and evenness combined (Hurlbert 1971; Rabenold 1978) but avoid emphasis on this index. Bird weights and derived population biomasses were based on published data (Stewart 1937; Poole 1938; Stegeman 1955; Tordoff and Mengel 1956; Johnston and Haines 1957; Graber and Graber 1962; and Murray and Jehl 1964) and our survey data. Bird and vegetation nomenclature follow American Ornithologists Union (1983) and Lakela (1965), respectively.

RESULTS

For each community, the breeding bird richness and density were plotted (figure 1). Four distinct clusters, which corresponded to community age, were identified. Early successional communities

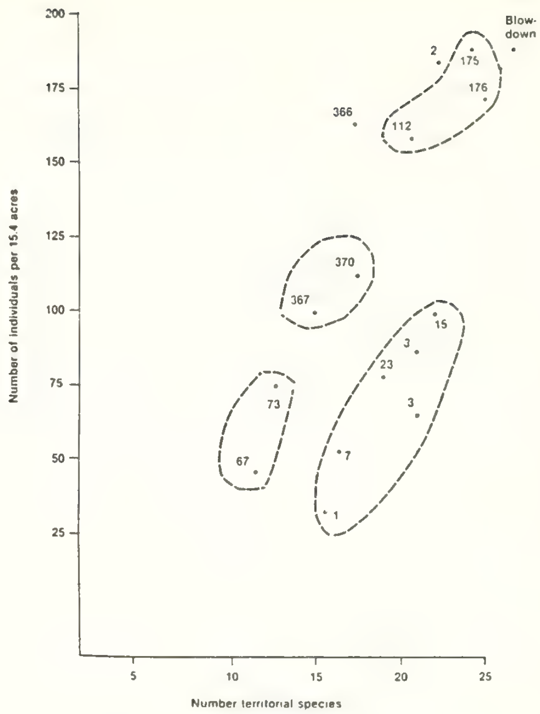

Figure 1.--Richness and density of territorial bird species by community.

(1 to 23 years-old) had nearly as many species but only half the bird density as mature communities (112 to 176 years after fire). Intermediate communities, 67 and 73 years after fire, had fewer species than the early successional communities, but similar densities. Compared to other communities, oldgrowth communities, 367 and 370 years after fire, were intermediate in number of species and individuals.

Three communities had markedly different bird species richness and density than other communities of comparable ages (figure 1). The 366 year-old community was small and immediately adjacent to the "blow-down" community; consequently, a higher bird richness and density compared to the other oldgrowth communities was measured. Likewise, the two-year community was on a steep ridge close to water and near a large bog; it, too, had unusually high bird populations compared to similarly aged communities. Lastly, the blow-down community, unlike early fire succession, had more species and higher density (figure 1). We eliminated these three communities from our successional comparisons.

Average relative importance values of the 48 breeding bird species were summarized by guild and community type (table 1). Twenty-one additional species, either peripheral to the study sites or transient through the grids, some as late migrants, are recognized by guild. The Ruby-throated Hummingbird and 3 raptor species were not assigned to a guild. Transients are listed as either occasional visitors (OV) or frequent visitors (FV), based on whether they were seen in more than one-quarter of the surveys. None of the

69 species recorded were found in all communities, but 11 of the most important nesting species were present in at least 11 of 13 communities (table 1).

Successional trends were evident. Based on importance values, recently disturbed communities (1 to 23 years-old) were dominated by White-throated Sparrows, Chestnut-sided Warblers, Mourning Warblers, and Black-backed Three-toed Woodpeckers. The Olive-sided Flycatcher and other flycatchers were most common the first three years after fire.

In the 67 and 73 year-old communities, Blackburnian and Bay-breasted Warblers attained the greatest relative importance of any species. The Ovenbird was one of four Ground-brush Foragers found nesting in the sparse, park-like understory of this forest. In the canopy, the Red-eyed Vireo was important.

In the 112 year-old forest, bird species composition was similar to the 67 and 73 year-old forests, but species importance ranks were different. Moreover, the bird species richness and density were similar to the mature communities. In the heavier spruce and fir cover of the 112 year-old forest, the Bay-breasted Warbler was relatively more important than the Blackburnian Warbler. The Red-eyed Vireo, a nearly ubiquitous Tree-foliage Searcher, was about equally important as the Black-throated Green and Black-throated Blue Warblers. Golden-crowned Kinglets were more important in this community than in others we studied. The Brown-creeper, nesting in 14 of the 16 communities, was dominant among the Timber Gleaners. Only the Ovenbird was relatively important among the Ground-brush Foragers.

In the other mature forests, 175 and 176 years after fire, more species of Tree-foliage Searchers were measured than in other communities, with the most important being Blackburnian and Bay-breasted Warblers. The Ground-brush Foragers increased in importance, compared to the 73-year forest, but no species predominated.

Oldgrowth forest, compared to intermediate and mature communities, had more Ground-brush Foragers. Tree-foliage Searchers were important, but no species was consistently dominant. Species that tended to be associated with oldgrowth communities were the Canada and Parula Warblers.

Species richness, based on average number territorial species in each of the four community age groups, varied from 11 to 22 species in the sere (table 2). After the first year, species richness was nearly constant for several years, and about equal to that in mature forests. When transient species were included, about the same number of species used the recently burned and mature communities. The 67 and 73 year communities, in contrast, had the lowest richness and diversity of avian species (table 2). Bird species richness peaked, again, in the 176 year-old community then declined in the oldgrowth communities.

Table 1.--Average importance values, based on relative frequency, relative cover of territories, and relative existence energy, of species in four community types that develop on upland sites after wildfire. Bird species nesting in the community type, but outside survey grids, are indicated as peripheral (P). Those that did not nest in the communities, but visited them during the breeding season, are evaluated as occasional visitors (OV) or frequent visitors (FV). Nomenclature follows AOU Checklist (1983) 6th Ed.

GUILD (All species)	Community Type (number of communities surveyed)			
Species	Early (6)	Intermediate (2)	Mature (3)	Oldgrowth (2)
FLYCATCHERS	20	8	7	5
Common Nighthawk	FV			
Eastern Wood Pewee	4			
Least Flycatcher	4	8	5	5
Olive-sided Flycatcher	12		2	
Tree Swallow	FV			
TREE-FOLIAGE SEARCHERS	77	220	84	210
Bay-breasted Warbler	2	46	38	45
Black-billed Cuckoo	1			
Blackburnian Warbler	9	89	38	41
Black-capped Chickadee			3	
Black-throated Blue Warbler			4	
Black-throated Green Warbler	1		10	16
Boreal Chickadee	3	12	5	4
Common Yellowthroat	P			
Canada Warbler	4		6	18
Cape May Warbler			2	
Cedar Waxwing	OV			
Evening Grosbeak	FV			
Golden-crowned Kinglet			7	
Magnolia Warbler	7	OV	12	9
Parula Warbler	1		2	15
Pine Grosbeak		OV		
Pine Siskin		6		
Red-eyed Vireo	20	22	17	P
Rose-breasted Grosbeak	9		14	16
Ruby-crowned Kinglet	2	22	16	18
Solitary Vireo	OV	4	6	7
Yellow-rumped Warbler	16	19	4	21
Yellow-throated Vireo	P			
TIMBER DRILLERS	22		13	
Black-backed Three-toed Woodpecker	15			
Downy Woodpecker	1		1	
Hairy Woodpecker	2		5	
Northern Three-toed Woodpecker	2			
Pileated Woodpecker	OV	FV	FV	FV
Yellow-bellied Sapsucker	2	FV	7	
TIMBER GLEANERS	23	18	25	19
Black-and-white Warbler	7			
Brown Creeper	14	12	6	16
Red-breasted Nuthatch	2	6	9	3
GROUND-BRUSH FORAGERS	158	53	72	67
Blue Jay	FV	FV	FV	FV
Brown Thrasher	1			
Chestnut-sided Warbler	20		6	
Chipping Sparrow	8	8	4	
Common Crow	OV			
Common Flicker	7		OV	OV
Common Grackle	FV		OV	
Common Raven	OV	OV	OV	
Common Snipe	OV			
Dark-eyed Junco	8		4	12
Gray-cheeked Thrush	3		6	
Grey Jay	FV	FV	IV	
Hermit Thrush	2	3		
Mourning Warbler	18		4	10
Nashville Warbler	15	11		
Northern Waterthrush	2			5
Overbird	8	28	18	
Purple Finch	5	OV		14
Robin	10		4	
Ruffed Grouse	FV		FV	
Song Sparrow	P			7
Spruce Grouse		FV	OV	
Starling	OV			
Swainson's Thrush	4		10	
Swamp Sparrow	4			
Veery	3		1	
White-throated Sparrow	36		11	12
Winter Wren	4	3	4	7
OTHER SPECIES	1			
American Kestrel	FV			
Broad-winged Hawk	OV			
Ruby-throated Hummingbird	1			
Sharp-shinned Hawk	OV			
TOTAL---ALL GUILDS	300	299	301	301

Table 2.--Summary of guild parameters by community type. Early, intermediate, mature, and oldgrowth communities are represented by communities 1 to 23, 67 to 73, 112 to 176, and 367 to 370 years after fire, respectively. All data are community averages based on 15.4 acre grids.

GUILD / Parameter	Community Type (number of communities surveyed) Early (6)	Intermediate (2)	Mature (3)	Oldgrowth (2)
TOTAL: ALL GUILDS				
No. breeding species	18.0	11.0	22.3	15.0
No. visiting/transient species	7.7	6.5	5.3	3.5
H' (base 10)	1.11	.86	1.12	1.05
Mean wt./individual (gm)	18.6	11.5	13.8	12.6
No. Individuals/15.4 acres	75	69	180	114
Population biomass (gm/15.4 acres)	1395	789	2529	1427
Total existence energy (Kcal/day)	1063	783	2161	1388
Existence energy /gm	.87	.99	.86	.97
FLYCATCHERS				
No. breeding species	1.8	.5	1.0	.5
No. visiting/transient species	1.1	0	0	0
H' (base 10)	.15	--	.13	--
Mean wt/individual (gm)	26.9	10.5	13.2	10.4
No. individuals/15.4 acres	2.0	1.0	2.3	2.0
Population biomass (gm/15.4 acres)	54	11	29	22
Total existence energy (Kcal/day)	55	11	29	23
Existence energy/gm (Kcal/day/gm)	1.02	1.05	1.00	1.05
TREE-FOLIAGE SEARCHERS				
No. breeding species	5.5	6.5	12.0	9.0
No. Visiting/transient species	1.2	2.0	0	0
H' (base 10)	.59	.64	.87	.97
Mean wt/individual (gm)	13.8	10.7	11.4	12.2
No. individuals/15.4 acres	17.8	49.5	132.7	86.5
Population biomass (gm/15.4 acres)	246	530	1513	1055
Total existence energy (Kcal/day)	308	547	1451	1053
Existence energy/gm (Kcal/day/gm)	1.25	1.03	.96	1.00
TIMBER GLEANERS				
No. breeding species	1.5	1.5	2.0	1.0
No. visiting/transient species	0	0	0	0
H' (base 10)	.14	.15	.28	.09
Mean wt/individual (gm)	8.6	8.0	8.9	8.2
No. of individuals/15.4 acres	7.0	6.0	15.5	7.5
Population biomass (gm/15.4 acres)	60	48	138	62
Total existence energy (Kcal/day)	67	56	120	67
Existence energy/gm (Kcal/day/gm)	1.12	1.17	.87	1.08
TIMBER DRILLERS				
No. breeding species	1.2	0	1.3	0
No. visiting/transient species	.7	0	1.3	1.0
H' (base 10)	.14	--	.15	--
Mean wt/individual (gm)	58.6	--	50.4	--
No. individuals/15.4 acres	2.0	0	3.0	0
Population biomass (gm/15.4 acres)	103	0	151	0
Total existence energy (Kcal/day)	55	0	72	0
Existency enery/gm (Kcal/day/gm)	.53	--	.48	--
GROUND-BRUSH FORAGERS				
No. breeding species	7.9	2.5	6.3	4.5
No. visiting/transient species	4.7	3.5	4.3	2.5
H' (base 10)	.75	.30	.68	.62
Mean wt/individual (gm)	20.5	15.2	23.7	15.5
No. individuals/15.4 acres)	40.0	11.5	29.0	18.0
Population biomass (gm/15.4 acres)	735	175	687	286
Total existence energy (Kcal/day)	572	169	489	246
Existence energy (Kcal/day/gm)	.78	.97	.71	.86

The importance values of guilds, being derived from the sum of the importance values of member species, also were related to time since fire (table 2). Flycatchers the first few years after fire had two to four times the biomass and existence energy as flycatchers in older communities. Tree-foliage Searchers were most important as the spruce-fir forest matured 112 to 176 years after fire. Timber Gleaners, primarily the Brown Creeper and Red-breasted Nuthatch, occurred almost evenly in nearly all communities. Timber Drillers were most important the first three years after fire, solely from the heavy use of recent burns by the Black-backed Three-toed Woodpecker. Ground-brush Foragers were more common in recently burned communities.

Eighteen species were recorded as visitors only; nearly half were Ground-brush Foragers (table 2). Some, such as the Blue Jay, and Pileated Woodpecker, were found in almost all communities, but most visitation occurred the first three years after fire. Encounters with visiting species were about twice as frequent in recent burns compared to communities 23 years and older.

Average bird weight was greatest for species using recently burned communities (table 2). A similar value was found in the three older community types. In younger communities, greater average mass of birds resulted from increased importance of Ground-brush Foragers, Flycatchers, and Timber Drillers.

Intermediate communities (67 to 73 years-old) had bird population biomasses that were 32 percent less than early communities and 50 percent less than mature communties (table 2). Existence energy for the avifauna followed the same trend. Energy efficiency, based on kilocalories per day per gram of bird weight, was greatest in mature and early successional communities, where diversity was highest. On the average, Timber Gleaners used the greatest amount of energy per gram of body weight; Timber Drillers used the least.

Taking each community as a separate treatment, comparison of bird density per grid segment yielded highly significant differences ($P<.005$), attributable to community age. In comparing individual communities by least significant difference ($P<.05$), no significant differences were found among the intermediate communities or the mature communities. The three oldest communities differed, indicating more variance among them. Similarily, we found considerable variance among the early communities.

DISCUSSION

In this fire sere, avian successional trends differed from trends for fallowed agricultural land (Adams 1908; Odum 1950; Johnston and Odum 1956). We found high species richness and diversity, comparable to mature communities, within two years following intense wildfire, and a reduction in species richness and diversity 67 and 73 years after fire. Johnston and Odum (1956) found increasing bird species richness and diversity during succession on abandoned Georgia farmland, however, only Ground-brush Foragers were present for the first 20 years. All guilds were represented in the fire sere through 370 years of succession. In the agricultural sere, a drop in species richness and diversity of birds occurred after 20 to 40 years, as grass and shrub communities gave way to canopied pine forests. This drop may correspond to the low diversity and richness of our intermediate communities. Bird density in the Great Lakes conifer forest increased up to 175 years and then decreased in the oldgrowth communities unlike the agricultural sere, where density declined after 90 years of succession.

Kendeigh (1946) reported avian density trends in Michigan similar to Johnston and Odum's findings.

Our data are in general agreement, although we clearly found higher densities in mature spruce-fir forests than in oldgrowth communities.

Our data support the conclusion (Theberge 1976) that species richness and total density are positively correlated. We found these two variables to most clearly separate the bird communities into community type. These community types, based on bird population parameters, corresponded well to observations of vegetation.

Twelve types of upland plant communities occur in the Boundary Waters Wilderness, four of which have jack pine (Pinus banksiana) as a dominant or co-dominant (Ohmann and Ream 1972). All of our study sites matched Ohmann and Ream's "jack pine-black spruce" and "jack pine-fir" community types. These correspond to the Society of American Foresters' (1954) Forest Cover Type 6, occupying slopes and ridges, especially over glacial till and rock outcrops, particularly with north to northeast exposures. In all study areas, jack pine communities represented patches in a mosaic that also included aspen (primarily Populus tremuloides with some P. grandidentata) dominated draws and small black spruce (Picea mariana) bog communities. Successionally, jack pine and aspen gave way to spruce and balsam fir (Abies balsamea).

Early Communities

Within two years after fire, upland communities had abundant dead, standing trees with heavy infestation of wood-boring and bark-dwelling beetles; percent of fire-killed trees varies depending on site, fire conditions and age of the community before fire (Apfelbaum and Haney 1981). The more severe the fire, often, the heavier the regrowth of ground cover. In addition to jack pine, scattered black spruce seedlings, and aspen seedlings and sprouts, many herbs and shrubs became established or resprouted; including fireweed (Epilobium angustifolium), thimble-berry (Rubus parviflorus), big-leaved aster (Aster macrophyllus), geranium (Geranium bicknellii), fringed bindweed (Polygonum cilinode), roses (Rosa spp.), gooseberries (Ribes spp.), beaked hazel (Corylus cornuta), and grasses and sedges. Mature white (P. strobus) and red pine (P. resinosa) usually survived fire and reseeded in mineral soil. The appearance of early post-fire communities was one of heavy ground cover, standing dead trees, pockets of surviving trees, especially aspen in draws and black spruce in bogs, and scattered older white and red pine, if any existed in the community prior to fire.

Within 10 to 15 years, most fire-killed trees had fallen and the jack pine and aspen regrowth was 3 to 5 m tall. Under the dense canopy, many of the herbs and smaller shrubs were replaced by mosses and lichens. Grass and sedge dominated openings persisted on wetter sites, with willow (Salix spp.) and speckled alder (Alnus rugosa) thickets around the edges. Within 23 years, some of the dense jack pine became wind-thrown and the smallest trees began to die as they were suppressed by dominants.

Intermediate Communities

By 60 to 70 years after fire, the dense jack pine and aspen forests had matured and thinned to more open, evenly spaced, homogeneous forests with dense carpets of lichens and bryophytes. Openings, except for lichen-dominated rock exposures, were filled with black spruce on wet sites and ericaceous shrubs (Vaccinium spp. and Gaylussacia spp.) on excessively drained sites. Spruce and fir were scattered in the canopy and were common seedlings and transgressives in the understory. Aspen draws in contrast to jack pine slopes, retained more shrub and herbaceous understory, especially willow, and establishment of spruce and fir may be farther advanced.

Mature Communities

Mature communities developed within 100 to 150 years. The canopy of the 112 year-old stand was comprised of scattered oldgrowth jack pine and aspen, often as overstory, among increasing numbers of spruce and fir of differing size classes. The community had more structural diversity than preceding communities. Shrub species were common, especially beaked hazel, dogwood (Cornus rugosa), and mountain maple (Acer spicatum). Ground cover of bryophytes, Clinton's lily (Clintonia borealis), bunchberry (Cornus canadensis), big-leaved aster and other herbs, as well as seedlings of spruce and fir was well developed.

By 175 years, dominant tree cover was a multi-layered canopy of spruce, fir, and, occasionally, residual red and white pine. The understory was dense young trees, shrubs, and herbs, all mentioned above. The mature forests were characterized by dense vegetation, more so than any other community.

Oldgrowth Communities

The oldest communities were characterized by scattered old red and white pine that formed an overstory in a somewhat open forest of spruce and fir. Most of the mature community species were also present. Pockets of disturbance, especially blowdown of large trees, resulted in diverse openings in which white and red pine regenerated, along with spruce and fir, and many of the shrubs and herbs found in younger communities. The oldest stand we studied, a 370 year-old community, had an important component of northern white-cedar (Thuja occidentalis); in the absence of disturbance, upland forests may succeed to northern white-cedar (Grigal and Ohmann 1975).

The decline of the homogeneous jack pine and aspen forest after 73 years was related to increasing cover of black and white spruce and balsam fir, layers of strata, and diversity of plant species. As jack pine and aspen dominants began dying, a hundred years into the sere, patchiness increased, leaving openings for spruce and fir to grow. These changes may have collectively increased bird species diversity from 73 years to 176 years. Oldgrowth communities, in general, had more open

canopies, more patchiness, and higher plant species diversity than mature communities. The decline of bird species diversity, therefore, in these oldgrowth communities, may support the conclusion that canopy cover was one of the more important factors controlling bird populations (Whitmore 1975, 1977).

In the Great Lakes Pine Transition Forest, where fire is a regular perturbation, recurring an average of every 100 years (Heinselman 1973), many bird and plant species have adapted to this disruption and reestablish quickly. For example, jack pine regenerates well only after fire and the Black-backed Three-toed Woodpecker specializes on insects beneath the bark of fire-killed pine and spruce. Other species that used early successional communities after fire included the Chestnut-sided Warbler, White-throated Sparrow, and Olive-sided Flycatcher. Many other species were opportunistic. These species were generalists and responded to disturbances more readily than others. Caswell (1976) and Huston (1979) noted that disturbance should disrupt dominant species and open opportunities for establishment of additional species or increase in populations that were previously less dominant, thus increase evenness. This can also be interpreted to suggest that disturbance should lead to disruption of well defined niches and create opportunities for generalists. Collectively, therefore, high species richness and diversity after fire resulted from habitat heterogenity, opportunities for species uniquely adapted to early successional communities, and increased opportunities for generalists.

Increased evenness of species after disturbance has also been reported for birds (Noon and others 1979) and spiders (Coyle 1981) after disruption of hardwood communities by logging. Evenness is suggested in our data by the nearly equal diversity index of early and mature communities while early communities had 20 per cent fewer species (table 2), diversity being a measure of species richness and evenness.

The decline we saw in bird species richness and density in the oldgrowth communities, compared to mature communities, may reflect the temporal and spatial isolation of these uncommon communities. We see no evidence of a long-term, stable community, based on bird populations, but rather an ecological system adapted to recurring fire.

Wilderness management in the Quetico-Superior should address the dependency of this system on fire. With fire suppression, we anticipate that wind, insects, and disease will play increasingly important and unknown roles in affecting community diversity. Ecological adjustments in populations and community structures may occur.

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REFERENCES

Adams, C.C., 1908. The ecological succession of birds. Auk 25:109-153.

American Ornithologists' Union, 1983. A.O.U. Check-list of North American Birds. Washington, D.C., Sixth Edition.

Apfelbaum, Steven; Haney, Alan; 1981. Bird populations before and after wildfire in a Great Lakes pine forest. Condor 83:347-354.

Austin, D.D.; Perry, M.L.; 1979. Birds in six communities within a lodgepole pine forest. Journal of Forestry 77:584-586.

Bock, C.E.; Lynch, J.F.; 1970. Breeding bird populations of burned and unburned forests in the Sierra Nevada. Condor 72:182-189.

Bock, C.E.; Raphael, M.; Bock, J.H.; 1978. Changing avian community structure during early post-fire succession in the Sierra Nevada. Wilson Bulletin 90:119-123.

Caswell, H.H., 1976. Community structure: a neutral model analysis. Ecological Monographs 46:327-354.

Coyle, F.A., 1981. Effects of clearcutting on the spider community of a Southern Appalachian forest. Journal of Arachnology 9:285-298.

Curtis, J.T., 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison. 657 pp.

Day, Robert, 1976 April 10. Telephone conversation.

Graber, R.R.; Graber, J.W.; 1962. Weight of characteristics of birds killed in nocturnal migration. Wilson Bulletin 74:74-88.

Grigal, D.F.; Ohmann, L.F.; 1975. Classification, description, and dynamics of upland plant communities within a Minnesota Wilderness area. Ecological Monographs 45:389-407.

Haapanen, A; 1965. Bird fauna of the Finnish forests in relation to forest succession. I. Annales Zoologici Fennici 2:329-382.

Heinselman, M.L., 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quaternary Research 3:329-382.

Heinselman, M.L., 1976 May 20. Conversation at Ely, MN.

Heinselman, M.L., 1976. Stand origin maps for Superior National Forest. Unpublished maps on file at: U.S. Dept. of Ag., For. Serv. Superior National Forest, Duluth, MN.

Hurlbert, S.H., 1971. The nonconcept of species diversity: critique and alternative parameters. Ecology 52:557-568.

Huston, M., 1979. A general hypothesis of species diversity. American Naturalist 113:81-101.

Johnston, D.W.; Haines, T.P.; 1957. Analysis of mass bird mortality in October 1954. Auk 74:447-458.

Johnston, D.W.; Odum, E.P.; 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37:50-62.

Kendeigh, S.C., 1944. Measurement of bird populations. Ecological Monographs 14:69-106.

Kendeigh, S.C., 1946. Breeding birds of the beech-maple-hemlock community. Ecology 27:226-245.

Kendeigh, S.C., 1970. Energy requirements for existence in relation to size of bird. Condor 72:60-65.

Kricher, J.C., 1973. Summer bird species diversity in relation to secondary succession on the New Jersey Piedmont. American Midland Naturalist 89:121-137.

Lakela, O., 1965. A Flora of Northeastern Minnesota. University of Minnesota Press, Minneapolis. 541 pp.

MacMahon, J.A., 1980. Ecosystems over time: succession and other types of change; pp. 27-58. In: Waring, R.H., editor. Fresh perspective from ecosystem analysis: Proceedings of 40th Annual Biological Colloquim;1980. Oregon State University, Corvallis, Oregon State University Press. 320 pp.

Maissurow, D.K., 1941. The role of fire in the perpetuation of virgin forests of northern Wisconsin. Journal of Forestry 39:201-207.

Meslow, E.C.; Wight, H.M.; 1975. Avifauna and succession in Douglas-fir forests of the Pacific Northwest; pp.12-18. In: Editor unknown. Management of forest and range habitats for non-game birds: Proceedings of symposium; General Technical Report WO-1. U.S. Dept. of Ag., Forest Serv.; Washington, D.C.

Murray, G.B.; Jehl, J.R.; 1964. Weights of autumn migrants from coastal New Jersey. Bird Banding 35:253-263.

Niemi, G.J., 1978. Breeding birds of burned and unburned areas in northern Minnesota. Loon 50:73-84.

Noon, B.R.; Bingman, V.P.; Noon, J.P.; 1979. The effects of changes in habitat on northern hardwood forest bird communities; pp. 33-48. In: Degraf, Richard, M.; Evans, Keith, E., compilers. Management of Northcentral and Northeastern forests for nongame birds: workshop proceedings; 1979 January 23-25; Minneapolis, MN: General Technical report NC-51. St. Paul, MN: U.S. Department of Ag., Forest Service. North Central Forest Experiment Station. 268 pp.

Odum, E.P., 1950. Bird populations of the highlands (North Carolina) plateau in relation to plant succession and avian invasion. Ecology 31:587-605.

Ohmann, L.F.; Ream, R.R.; 1972. Wilderness ecology: virgin plant communities of the Boundary Waters Canoe Area. Research Paper NC-63. St. Paul, MN: U.S. Dept. of Ag., Forest Service, North Central Forest Experiment Station.

Poole, E.L., 1938. Weights and wing areas of North American birds. Auk 55:511-517.

Rabenold, K.N., 1978. Foraging strategies, diversity, and seasonality in bird communities of Appalachian spruce-fir forests. Ecological Monographs 48:397-424.

Society of American Foresters, 1954. Forest cover types of North America (exclusive of Mexico). Washington, D.C. 76 pp.

Stegeman, L.C., 1955. Weights of small birds in central New York. Bird Banding 26:19-27.

Stewart, P.A., 1937. A preliminary list of bird weights. Auk 54: 324-332.

Taylor, D.L.; Barmore, W.J., Jr.; 1980. Post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Park, Wyoming; pp. 130-145. In: Editor unknown. Management of western forests and grasslands for nongame birds: workshop proceedings; 1980; General Technical Report INT-86; Ogden UT: U.S. Dept. of Ag., Forest Service, Intermountain Forest and Range Experiment Station.

Taylor, D.L., 1973. Some ecological implications of forest fire control in Yellowstone National Park, Wyoming. Ecology 54:1394-1396.

Theberge, J.B., 1976. Bird populations in the Kluana Mountains, southwest Yukon, with special reference to vegetation and fire. Canadian Journal of Zoology 54:1346-1356.

Tordoff, H.B.; Mengel, R.M.; 1956. Studies of birds killed in nocturnal migration. Manhattan; University of Kansas, Publication of Museum of Natural History 10:1-44.

Whitmore, R.C., 1975. Habitat ordination of passerine birds of the Virgin River Valley, southwestern Utah. Wilson Bulletin 87:65-75.

Whitmore, R.C., 1977. Habitat partitioning in a community of passerine birds. Wilson Bulletin 89:253-265.

Williams, A.B., 1936. The composition and dynamics of a beech-maple climax community. Ecological Monographs 6:317-408.

STRUCTURE AND PROCESS GOALS FOR VEGETATION IN WILDERNESS AREAS

James K. Agee and Mark H. Huff

ABSTRACT: Goals for vegetation management in wilderness areas have been difficult to define. Managing for natural vegetation is confounded because "natural" is not uniquely defined and past interruption of natural processes, particularly fire, has caused ecosystem changes that may be difficult to remove. To what extent can we or should we structurally recreate the ecosystems that would have been present today without past human interference before reintroducing natural fire regimes? Short return interval, low-intensity fire regimes offer the most promise for structurally oriented vegetation management goals, although there are some long-return interval or high-intensity fire regimes where such goals may be preferred. Process-oriented goals are suitable for all fire regimes but in some cases should be integrated with structural goals for short fire-return interval ecosystems.

INTRODUCTION

Goals for managing vegetation in wilderness areas are seemingly paradoxical. Wilderness legislation dictates that such areas be "primeval", "natural", and "affected primarily by the forces of nature". How, then, can a management regime be consistent with this legislative mandate? Active manipulation and management of wilderness ecosystems may be needed to remove past unnatural influences caused by modern humans, and to actively reestablish natural processes in these wilderness ecosystems.

Wilderness vegetation goals can differ significantly from vegetation management goals on other lands. Lands managed for timber production may have goals specified in total wood volume, or in physical dimensions of particular tree species. Lands managed for historical values may have vegetation goals stated in terms of historical scenes at some past time. In both cases very specific structural endpoints can be specified. In contrast, the perfect "natural" wilderness vegetation will consist of native vascular and nonvascular plants arranged in a natural architecture at the organizational level of the point, the stand, and the landscape, and affected by a variety of natural disturbance factors. Both structure and process-oriented goals are possible to define for wilderness ecosystems.

Intelligent wilderness management requires simulation or shepherding of natural disturbance patterns over the landscape. Some are beyond immediate management control: glaciers, volcanic eruptions, windstorms. Others, such as fire, have been intimately involved with human activity for thousands of years as well as with more universally accepted natural origins (lightning, volcanoes). The extent to which pretechnological humans are considered natural is discussed by Kilgore (1985); as long as a decision is made for each wilderness on whether Indian burning is or is not considered natural, reasonable goals for wilderness vegetation management can be considered in that context.

Fire is one of the most important vegetation disturbance agents in most North American wilderness. Its proper role has been characterized in terms of both structure and process-oriented goals (Bonnicksen 1985; Bancroft and others 1985). Do we want a natural fire regime (process), or rather the vegetation that a natural fire regime would have created (structure) (Van Wagner 1985)? Process goals focus on the use of scheduled or unscheduled ignitions to recreate the range of fire frequencies, intensities, and extents that the wilderness would have or should experience in the absence of past, present, or future human intervention. Structural goals focus on attributes of vegetation that would be considered natural, also in the absence of human intervention.

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We submit that neither structure nor process can be exclusively defended as appropriate wilderness vegetation management goals. Both can be interpreted as being mandated by the Wilderness Act; conversely, both can be criticized for not producing truly natural vegetation. The issue becomes which is most appropriate in a certain situation. The following analysis suggests that the natural fire regime, the size of the area, and the degree of past intervention by humans all affect the types of goals most appropriate for a given wilderness. Process-oriented goals appear to have a wider applicability than structurally oriented goals, but in some cases an integration of both goals may be necessary to recreate and maintain natural wilderness ecosystems.

WILDERNESS WITH FREQUENT FIRE

Debate over structural versus process goals has concentrated in ecosystems with frequent, low-intensity fires in California. For these mixed-conifer ecosystems, the process-oriented goal is to restore or maintain the natural fire regime (Bancroft and others 1985). It is predicated on the belief that pre-suppression structural elements of the system are largely intact, and that fire can reduce fuels, thin understory tree thickets created during the fire suppression era, and create a natural suite of effects by burning in a mosaic pattern through the forest. The structure-oriented goal is to restore the vegetation to a natural state pre-determined through extensive field sampling, reconstruction of pre-intervention conditions, and simulation of natural structural evolution to the present. After manipulation to recreate the natural state, natural processes can again be allowed to enter the system (Bonnicksen and Stone 1982). It is based on the premise that a fire burning in a forest of unnatural structure cannot be termed natural: structural restoration is first needed before fire can be reintroduced to the system.

The effectiveness of structure and process goals can be evaluated for other mixed-conifer wilderness ecosystems. In the Crater Lake Wilderness of southern Oregon, very similar forests occur (except that no giant sequoia (Sequoidendron giganteum) exists there). Ponderosa pine (Pinus ponderosa) is a fire-tolerant and shade-intolerant species favored by fire, and white fir (Abies concolor) is a shade-tolerant and fire-intolerant (when small) species that is favored by fire suppression (Kercher and Axelrod 1984; van Wagtendonk 1985). The structural characteristics of these systems appear to resemble the California forests. Species regenerate in single species clusters, the overstory is a mosaic of clusters, and ponderosa pine dominated the pre-fire-suppression era forests (Thomas 1982). Fire suppression for an average of four 15-20 year cycles has tended to mask this clustering effect by allowing thickets of white fir to develop in the understory. Many of the stands are growing on coarse-textured, volcanic deposits which favor shallow rooting.

Neither a rigid structure-oriented nor a rigid process-oriented approach seems appropriate for the Crater Lake Wilderness. Fires were reintroduced using a process-based research approach to mimic natural fire intensities and spread patterns by burning in more moist seasons of the year than mid-summer. When the burns were evaluated over a four-year period (Thomas and Agee, in prep.) pine mortality was significantly higher than expected, primarily because of postfire bark beetle attacks on sugar pine (Pinus lambertiana) and ponderosa pine. Susceptibility to beetle attack was hypothesized to occur from fine root mortality caused by fires smoldering in basal fuel accumulations around the trees. With localized seed sources gone and surviving white firs in the immediate area, future trends toward higher white fir dominance are likely.

An approach based on structure alone may not work significantly better. The most detailed structural model proposed for mixed conifer ecosystems (Bonnicksen and Stone 1982) based size-age correlations on a total of 248 samples for all height classes of all species, only a fraction of the data collected at Crater Lake. Because their structural model uses age data to move the system through time, the assumption of even-aged cohorts is not firmly grounded. Recent research in drier ponderosa pine forests has questioned the universality of even-aged group reproduction in these forests (White 1985), and the Crater Lake data do not clearly support an even-aged hypothesis within groups. The layers of assumptions necessary to implement a rigid structural model on a wide scale will produce a plan that is inherently value-laden and as unnatural as a pure process approach.

A more reasonable approach is to integrate both types of goals into a hybrid structure/process goal. Using such a goal, fire is reintroduced in a low-intensity mosaic pattern as the restorative tool, but attention is paid to structural elements that are not

easily replaced if removed by fire. For the pines at Crater Lake, this could mean raking debris from the bases of the trees (perhaps not necessary on all substrates but might be on pumice substrates). White fir mortality is of secondary importance because if large firs are killed there is abundant seed source and existing sapling to pole-sized firs to replace them.

The advantage of this approach is that fire will be allowed to choose the mosaic pattern within a fire prescription, skipping some patches and torching understory clumps in others, while protecting the pre-fire-suppression structural elements during the fuel reduction process. Eventually, the natural structure of the wilderness should be restored to a close mimic of what it would have been had we not suppressed fires for the past 80-100 years (fig. 1 [a-b]). The disadvantage of this approach is that some of the post-fire suppression cohort of white fir have grown large enough that fire cannot be used to remove them. This results in higher than normal white fir seed source and possible altered fire behavior caused by more white fir litter mixed into the forest floor. The young fir cohort might be cut down in a strict structural goal approach. If a hybrid approach is adopted, this cohort will have to be accepted as the price of adopting the goal, but this is clearly a more practical approach than one based purely on structure.

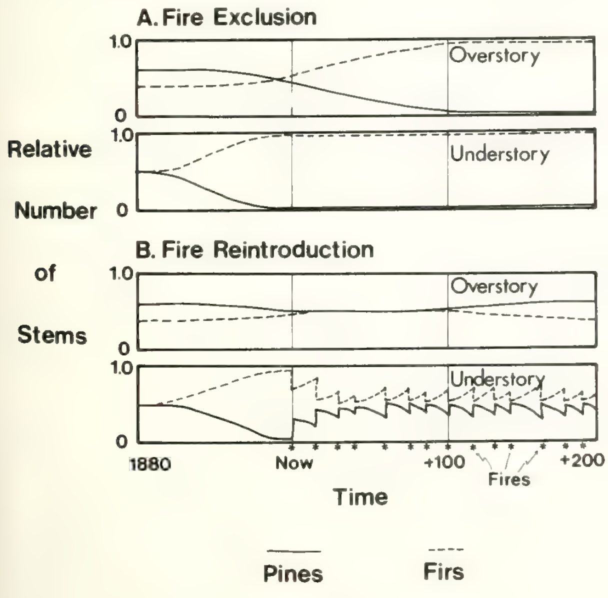

Figure 1.-- A. With fire exclusion, pines have been eliminated from the understory and will eventually be replaced in the overstory. B. With fire reintroduction, pines are able to regenerate in canopy openings and restore a natural balance of pines and firs. These schematics assume a stable climate and fire regime.

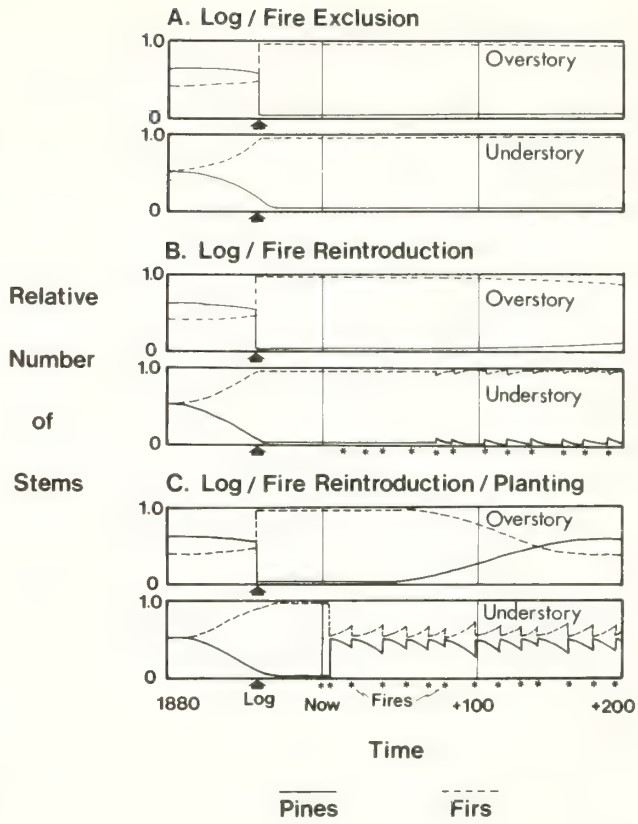

Figure 2.-- A. In areas where pines were selectively removed by logging, the conversion to fir is complete. B. Fire reintroduction alone cannot restore natural character to the forest due to lack of seed source. C. Creation of openings, if necessary, plus planting of pine, will restore a natural mosaic, although considerable time will be required.

Structural goals have and will continue to find application in ecosystems with short fire-return intervals, including wildernesses. In high-visibility areas and small wildernesses, structural solutions to restoration may be quicker and more esthetically pleasing. Along wilderness borders, a rapid conversion to natural structure may prevent damage from potential high-intensity wildfires moving in from adjacent lands. At one area within Crater Lake Wilderness, pines were selectively removed from the forest before it became part of the park. Without restoration, the natural dominance of pines will not occur (fig. 2a), because pine seed source is missing (fig. 2b). A structural approach is necessary because of the need to reintroduce pines to the landscape by creating canopy openings for them and planting them in a clustered fashion (or distributing seed) within canopy holes. Eventually, pine dominance is projected for these areas in the presence of periodic fires (fig. 2c).

WILDERNESS WITH INTERMEDIATE FIRE FREQUENCY

Wildernesses with intermediate fire-return intervals present the most complex fire regimes and also the most difficult ecosystems in which to evaluate structure/process objectives. These fire regimes have a frequency of 25-100 years with fire intensities ranging from surface fires to crown fires. The effects on the stand range from an understory thinning with little to no recruitment of new stems, through partial mortality with growing space created for a new age class, to a stand replacement event, usually on a small scale.

Many forest types in the western United States exhibit this type of fire regime: red fir in California (Pitcher 1981), xeric coastal redwood (Veirs 1982), and dry Douglas-fir forests of the Oregon Cascades (Means 1982; Morrison 1984) and Washington (Larson 1982; Agee and Dunwiddie 1984). Multiple age classes are often present (fig. 3a) where fires causing medium mortality have occurred, resulting in a complex mosaic of forest structures over the landscape (fig. 3b) and a variety of individual stand structure patterns (fig. 3c). Fire plays a role not only in shaping the mosaic but also in the development of individual patches of the mosaic, but with a much less predictable scenario than the mixed-conifer examples discussed earlier. What should be the appropriate vegetation management objective in such wilderness ecosystems?

In general, it appears that process-oriented objectives will better recreate and maintain these ecosytems than structure-oriented objectives. At any one point specific structural objectives appear very difficult to define. While an average fire interval may be 40 years, the variation around that mean is usually equal to or longer than the period of fire suppression (for example, Means 1982; Morrison 1984). The impact of fire suppression is therefore difficult to define, although certainly the natural role of fire was reduced during the fire suppression era. The interruption in the natural fire regime may also pose difficulties with process-oriented objectives. The absence of a mosaic of ignitions for decades may have resulted in more fuel homogeneity, higher probabilities of uniform fire spread and intensity, and a future landscape mosaic with larger-than-natural sized units. Where fires tend to stop at age class boundaries (for example, Romme 1980) such changes may be significant; their importance should be reviewed on a site-specific basis. The significance of more homogeneous fuels could be evaluated by monitoring future natural fires and/or by evaluating fire behavior in a range of stand structures using a predictive fire behavior modeling system such as BEHAVE (Burgan and Rothermel 1984). To some extent the outcome of either method is subjective.

Structural goals could be developed using estimations of patch size with attempts to recreate a natural mosaic of different sized patches with various structures by varying fire intensity

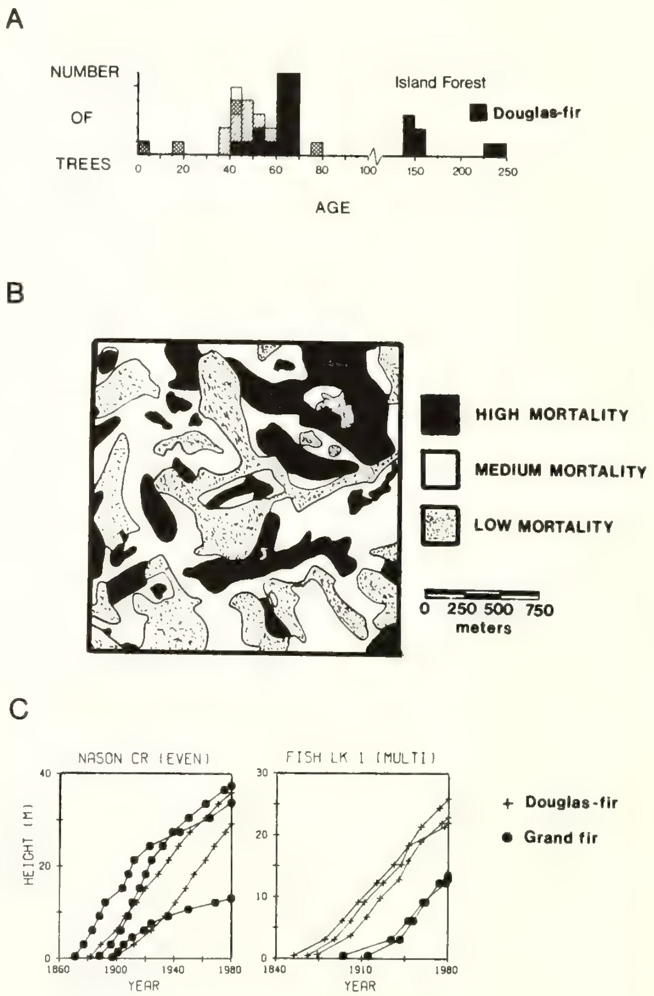

Figure 3.-- A. Stands with intermediate fire-return intervals are often multi-aged (from Agee and Dunwiddie 1984). B. Fire intensity varies across the landscape, creating patches of low, medium, and high mortality (from Morrison 1984). C. Several types of vertical stand structure may result from intermediate fire regimes: left, a multi-tiered structure with two species; right, a two-tiered structure with different species in each level (from Larson 1982).

within patches. Patches could be defined to be even-aged (stand replacement fires), multi-aged (partial mortality fires), or low understory thinned (low-intensity surface fires). This approach might be most appropriate in very small wildernesses where the typical variable intensity fire regime is considered too risky to implement.

Structural goals may also be appropriate for those actual or potential wildernesses that have been affected by human disturbances other than fire, particularly logging. In coast redwood forests, for example, Veirs and Lennox (1981) suggest that "naturalization" of cutover parklands can be accelerated by cultural treatment. Stands that were 25 years old after clearcutting could be thinned to produce redwood/Douglas-fir ratios characteristic of 60-year-old stands. While these areas do not resemble the primeval character associated with wilderness in a landscape sense, they may one day possess substantial wilderness character. Congress has already included substantially altered landscapes as wilderness; the point here is that a structural goal may be appropriate in a substantially altered ecosystem both in molding natural stand structures and managing natural disturbances in the interim. Structural goals in wildernesses with intermediate fire-return intervals appear to have high potential for artificiality. They are most suited to those situations where, because of the small size or high degree of human disturbance in wilderness, process-oriented goals are unsuitable.

WILDERNESSES WITH INFREQUENT FIRE

Wildernesses with long fire-return intervals and stand replacement fire intensities often have a fluctuating history of recent human-caused fire. Forests may show an increased fire frequency during the settlement period and decreased fire frequency in recent decades (for example, Hemstrom and Franklin 1982). Effects of fire suppression or increased fire activity are generally less noticeable at the stand level because fire is not intimately related to postfire stand development; rather, it "resets" the system to time zero on the successional "clock". Disruption of natural pattern may be more noticeable at the landscape level. For example, if the age class distribution of such a forest can be modeled using a negative exponential distribution (Van Wagner 1978), the natural age class distribution will appear as in figure 4a. Successful fire protection will shift the curve to the right over time (fig. 4b), preventing young age class mosaics from forming and allowing shade tolerant regeneration to replace pioneer trees in older stands.

If a process goal is implemented, reintroduction of fire will in theory result in a distribution (fig. 4c) with a gap that moves to the right with time and eventually disappears, very likely becoming insignificant after the mean stand age (equal to the length of the fire cycle) is reached. Several problems can nevertheless appear in the real wilderness with this process-oriented approach. First, the size of the average burned mosaic unit can increase due to the multi-decade interruption in the production of young stands that might have broken up fuel continuity. Because long fire-return

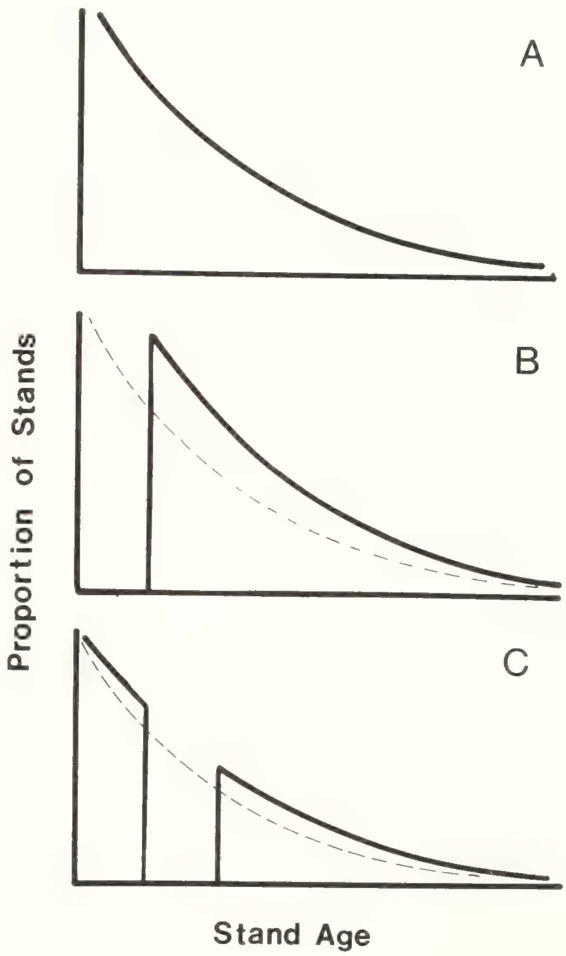

Figure 4.-- A. A forest with a negative exponential age distribution. B. The age distribution is skewed to the right with fire suppression (dashed line is graph A). C. A natural fire regime is reinstituted, and the age gap moves to the right with time.

interval systems are often characterized by high-intensity fires, wilderness fire managers may be forced to impose conservative flame length criteria in wilderness fire prescriptions, biasing fire effects to those of low-intensity fires as well as lengthening the fire cycle due to suppression constraints. If such a strategy is successful, the fire cycle will be prolonged and average fire intensity will be less. For a computer-modeled subalpine fir/blue huckleberry (Abies lasiocarpa/Vaccinium globulare) habitat type in the northern Rocky Mountains, Marsden (1983) suggested that such fire regime changes, together with bark beetle activity, would significantly alter the age structure and dominant vegetation of forest communities in the area (table 1). Much more Douglas-fir (Pseudotsuga menziesii) and subalpine fir and less lodgepole pine (Pinus contorta) would be present with lower intensity fires and longer fire cycles. Marsden recognized that this habitat type does sometimes burn with lower intensity fires, but the dominant type of fire is a stand replacement event (Davis and others 1980). Process goals may be sufficient for most wildernesses with long fire-return intervals, but if only partly implemented, they may produce an unnatural set of vegetation types.

Structural goals in the long fire-return interval wilderness may be very difficult to achieve. Using the negative exponential model again, the gap created by successful fire protection could be filled by silvicultural manipulation of young stands. An excess of young stands is created by additional stand replacement burning above natural levels in a variety of older age stands (fig. 5a); the excess stands (fig. 5b-c) are then thinned and fertilized to extend their "age" to mimic the structure of older stands. This high level of manipulation may be limited to small wildernesses which are intensively managed because of political or economic constraints, and could require additional measures such as planting if the fire cycle had been delayed so long that certain "pioneer" structural elements of the system (such as lodgepole pine) had disappeared from the system. It may be sufficient to recognize that a gap in age class

Table 1.--Cover of forest communities under two fire regimes for subalpine fir/ blue huckleberry habitat type (from Marsden 1983).

Forest Type	Age Class	% Cover Under Fire Cycle* of: 167 yr.	200 yr.
Pico-Psme-Abla**	1-250	64	10
Pico-Psme-Abla	81-200	--	5
Psme-Abla	1-250	18	35
Psme-Abla	251-399	14	19
Abla Climax		4	31
Total		100	100

*Concept of Van Wagner (1978). Since some of the 200 yr fire cycle fires are less than stand replacement intensity, the stand replacement fire cycle for those stands extends to 402 yrs.
**Pico= lodgepole pine
Psme= Douglas-fir
Abla= subalpine fir

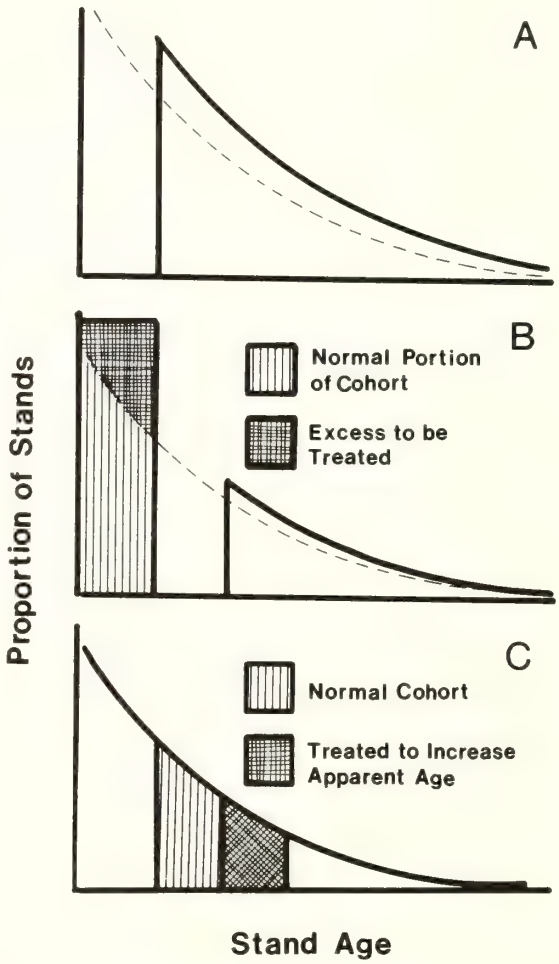

Figure 5.--A structural solution to the age class gap in figure 4B. A. The age class gap is in the younger age classes. B. "Excess" older stands are burned to provide a "surplus" of younger stands. C. The surplus stands are treated with thinning/fertilizing/pruning/underplanting to increase their apparent "age" and restore a natural-appearing age class distribution.

structure exists and renew the process goal in such systems. Where the negative exponential method has been tested (Van Wagner 1978), real forests do not precisely fit the curve anyway, so a gap may be within the range of natural variability in forest age class distribution.

In wildernesses with very long fire-return intervals, the impact of 6-8 decades of fire suppression has been minimal in terms of the distribution of age class mosaics. Agee and Flewelling (1983) evaluated the fire cycle for Olympic National Park based on climatic records for the 20th century. They estimated that the natural fire cycle for this century would have been about 3500 years compared to about 7000 years under the current fire suppression regime. Roughly 3000 ha have been "saved" by fire suppression activities over the modern period, a negligible figure for the 300,000 ha park. The effect of fire suppression in terms of total area or age class mosaic distribution has been small. Furthermore, the real forests appear to have a fire record substantially greater than that modeled with 20th century fire weather. Fire activity of past centuries appears to be very concentrated and may reflect significant climatic shifts (Agee and Flewelling 1983). The lack of a true cycle may cause structural recreations to be very probabilistic. In such cases, process-oriented goals are more likely to achieve natural wilderness character than structurally oriented goals.

In subalpine areas, where fire and climate interact, certain age classes of trees are unrelated to fire (Franklin and others 1971) and regeneration after fire may take 50-100 years (Agee and Smith 1984) (fig. 6). Forest age classes and the balance between meadow and forested environments may depend on climatic shifts and whether disturbance by fire is followed by cooler/warmer or drier/wetter episodes. Where forest development is independent of or not consistent after fire, pretechnological vegetation reconstructions may be meaningless in terms of future ecosystem dynamics; process-oriented goals are more sensible.

SUMMARY

Structural goals appear to be most applicable in wildernesses with short fire-return intervals, those wildernesses that are so small that natural fire patterns (frequency, intensity, and extent) cannot be achieved through process goals, or

Figure 6.--Subalpine burned sites in the Olympic Mountains at postfire ages 1, 55, and 90 indicate that size of fire, seed source, and climate after fire affect the rate of succession. Time since disturbance is, by itself, a poor index to predict succession.

wildernesses that have been severely altered by human intervention. Hybrid structure/process objectives may be more applicable in many wildernesses with short fire-return intervals, because fire as a process is interrelated with the structural evolution of those ecosystems. As fire-return intervals lengthen there are fewer cases where structure-oriented objectives possess major advantages over process-oriented ones.

There are no cases where either type of objective will recreate or maintain a totally natural wilderness ecosystem. Simply the presence of exotic flora and fauna precludes this. The pessimist in this situation might conclude that we should then manage fire in whatever fashion suits us, regardless of how close it mimics naturalness. To the optimist it suggests that we can come very close to a true wilderness setting. Recognizing the importance of selecting goals by which fire can be managed in wilderness will allow us to recreate and maintain these ecosystems for future generations. We will carry to future generations not a history of what wilderness was but a living, dynamic example of what it is and will be.

REFERENCES

Agee, J.K.; Dunwiddie, P.W. Recent forest development on Yellow Island, San Juan County, Washington. Can. J. For. Res. 62(10): 2074-2080. 1984.

Agee, J.K.; Flewelling, R. A fire cycle model based on climate for the Olympic Mountains, Washington. In: Seventh Conf. Forest and Fire Meteorology: Proceedings. Fort Collins, CO. Amer. Meteor. Soc.: 32-37. 1983.

Agee, J.K.; Smith, L. Subalpine tree reestablishment after fire in the Olympic Mountains, Washington. Ecology. 65(3): 810-819. 1984.

Agee, J.K.; Thomas, T.L. Forest restoration at Sun Creek, Crater Lake National Park. National Park Service Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Seattle. 1982. 38p. Unpub. Final Rpt. on NPS Contract CX-9000-1-E002.

Bancroft, L.; Nichols, T.; Parsons, D.; Graber, D.; Evison, B.; van Wagtendonk, J. Evolution of the natural fire management program at Sequoia and Kings Canyon National Parks. In: Lotan, J. and others, ed. Proceedings: Symposium and Workshop on Wilderness Fire. Gen. Tech. Rpt. INT-182. Ogden, UT: U.S. Dept. Agr., Forest Service, Intermountain Forest and Range Experiment Station; 1985: 174-180.

Bonnicksen, T. Ecological information base for park and wilderness fire management planning. In: Lotan, J. and others, ed. Proceedings: Symposium and Workshop on Wilderness Fire. Gen. Tech. Rpt. INT-182. Ogden, UT: U.S. Dept. Agr., Forest Service, Intermountain Forest and Range Experiment Station; 1985: 168-173.

Bonnicksen, T.; Stone, E.C. The giant sequoia - mixed conifer forest community characterized through pattern analysis as a mosaic of aggregations. For. Ecol. and Manage. 3(4): 307-328; 1981.

Davis, K.M.; Clayton, B.D.; Fischer, W.C. Fire ecology of Lolo National Forest habitat types. Gen. Tech. Rpt. INT-79. Ogden, UT: U.S. Dept. Agr., Forest Service, Intermountain Forest and Range Experiment Station; 1980: 77 p.

Franklin, J.F.; Moir, W.H.; Douglas, G.W.; Wiberg, C. Invasion of subalpine meadows by trees in the Cascade Range, Washington and Oregon. Arctic and Alpine Res. 3: 215-224; 1971.

Hemstrom, M.A.; Franklin, J.F. Fire and other disturbances of the forests in Mount Rainier National Park. Quaternary Res. 18: 32-51; 1982.

Kercher, J.R.; Axelrod, M.C. A process model of fire ecology and succession in a mixed-conifer forest. Ecology. 65: 1725-1742; 1984.

Larson, B.C. Development of even-aged and uneven-aged mixed conifer stands in eastern Washington. In: Means, J.E., Ed. Forest succession and stand development research in the Northwest: Proceedings. Corvallis, OR. Oregon State University: 113-118; 1982.

Marsden, M. Modeling the effect of wildfire frequency on forest structure and succession in the northern Rocky Mountains. J. Environ. Manage. 16: 45-62; 1983.

Means, J.E. Developmental history of dry coniferous forests in the western Oregon Cascades. In: Means, J.E., ed. Forest succession and stand development research in the Northwest: Proceedings. Corvallis, OR. Oregon State University: 142-158; 1982.

Morrison, P.H. The history and role of fire in forest ecosystems of the central western Cascades of Oregon determined by forest stand analysis. Seattle, WA: College of Forest Resources, University of Washington; 1984. 183 p. Master of Science professional paper.

Pitcher, D.C. The ecological effects of fire on stand structure and fuel dynamics in red fir forests of Mineral King, Sequoia National Park, California. Berkeley, CA: Department of Forestry, University of California; 1981. Master of Science thesis.

Romme, W.H. Fire frequency in subalpine forests of Yellowstone National Park. In: Stokes, M.A.; Dieterich, J.H., eds. Fire history workshop: Proceedings. Gen. Tech, Rpt. RM-81. Fort Collins, CO: U.S. Dept. Agr., Forest Service, Rocky Mountain Forest and Range Experiment Station; 1985: 27-30.

Thomas, T.L. Forest restoration of Sun Creek, Crater Lake National Park. Seattle, WA: College of Forest Resources, University of Washington; 1982. 113 p. Master of Science thesis.

Thomas, T.L.; Agee, J.K. Prescribed fire effects on mixed-conifer forest structure at Crater lake, Oregon. Seattle, WA: National Park Service Cooperative Park Studies Unit. 1985; 20 p. Unpublished manuscript.

Van Wagner, C.E. Age-class distribution and the forest fire cycle. Can. J. For. Res. 8: 220-227; 1978.

Van Wagner. C.E. Does nature really care who starts the fire? In: Lotan, J. and others, ed. Proceedings: Symposium and Workshop on Wilderness Fire. Gen. Tech. Rpt. INT-182. Ogden, UT: U.S. Dept. Agr., Forest Service, Intermountain Forest and Range Experiment Station; 1985: 98-100.

Van Wagtendonk, J.W. Fire suppression effects on fuels and succession in short-fire-interval wilderness ecosystems. In: Lotan, J. and others, ed. Proceedings: Symposium and Workshop on Wilderness Fire. Gen. Tech. Rpt. INT-182. Ogden, UT: U.S. Dept. Agr., Forest Service, Intermountain Forest and Range Experiment Station; 1985: 119-126.

Veirs, S.D. Coast redwood forest: stand dynamics, successional status, and the role of fire. In: Means, J.E., ed. Forest succession and stand development research in the Northwest: Proceedings. Corvallis, OR. Oregon State University: 119-141; 1982.

Veirs, S.D.; Lennox, W. Rehabilitation and long-term park management of cutover redwood forests: problems of natural succession. In: Coats, R.N., ed. Watershed rehabilitation in Redwood National Park and other Pacific coastal areas: Proceedings. Center for Natural Resource Studies, John Muir Institute and National Park Service; 1981: 50-55.

White, A.S. Presettlement regeneration patterns in a southwestern ponderosa pine stand. Ecology. 66: 589-594. 1985.

EVALUATING DIRECT RESPONSE TO UNDERSTORY BURNING IN A

PINE-FIR-LARCH FOREST IN GLACIER NATIONAL PARK

Bruce M. Kilgore

ABSTRACT: An 80-acre prescribed understory burn in a pine-fir-larch forest successfully killed 60 percent of the sapling Douglas-fir and spruce with little damage to overstory ponderosa pine and larch. A more intense, stand-replacing fire in a small lodgepole pine stand resulted in nearly 8,000 lodgepole pine seedlings per acre the first year after the burn. Down woody fuels were reduced by 30 percent. No control problems were experienced. National Park Service managers need to consider whether additional such burns are appropriate in the North Fork boundary zone of Glacier National Park.

INTRODUCTION

Fire has played an important role in the forests of the Northern Rocky Mountains, including Glacier National Park, MT, for thousands of years (Habeck and Mutch 1973). However, soon after establishment of the park in 1910, efforts were made to suppress all fires. In many areas, this resulted in a gradual accumulation of fuels and changes in forest structure and mosaic patterns (Lunan and Habeck 1973). Changes in National Park Service management policy since 1968 allow some lightning fires to burn under certain conditions, recognize prescribed burning as a proper tool of wildland management in ecosystems altered by prolonged exclusion of fire, and continue fire suppression in developed areas (Kilgore 1982).

Studies of fire effects have been carried out in ponderosa pine and sequoia-mixed conifer forests for more than 20 years (Weaver 1943; Biswell 1967; Hartesveldt and Harvey 1967; Kilgore 1973). Prescribed burning has been a standard management practice in the South for more than 40 years (Komarek 1973). Use of understory burning in the forests of Montana and the Northwest, however, is just beginning.

The research described here was carried out by the Forest Service research work unit, Fire Management in Natural Ecosystems. at the Intermountain Fire Sciences Laboratory in Missoula, MT. We worked cooperatively with Dr. Ronald Wakimoto of the University of Montana, Missoula, in seeking to help the National Park Service at Glacier National Park determine the appropriate mix of lightning fires, prescribed fires, and suppression in various areas of the park to restore a close approximation of fire's natural role (Wakimoto 1984). To learn more about the role of fire in this ecosystem, a low- to moderate-intensity prescribed understory burn was carried out, and measurements were made of vegetative and fuel characteristics of the system before and after burning.

The broad objectives of the experimental burn were to: (1) restore natural processes to the pine-fir-larch forest typical of stands near the park boundaries on the North Fork Flathead River; (2) reduce fuel accumulations in the forests along the boundary; and (3) expose some mineral soil and prepare a seedbed for ponderosa pine seed germination and seedling survival.

Specific burn objectives were to:

1. Reduce downed woody fuels by 50 to 80 percent.
2. Kill nearly 60 percent of the understory conifers (Douglas-fir, lodgepole pine, and spruce less than 6 inches d.b.h.);
3. Prevent more than 50 percent crown scorch on mature ponderosa pine;
4. Prevent mortality of more than 10 percent of the mature ponderosa pine;
5. Expose 15 to 35 percent of the mineral soil, and allow establishment of ponderosa pine seedlings;
6. Rejuvenate the successional cycle of native shrubs, forbs, and grasses; and
7. Prevent escape or trespass fires.

STUDY AREA

The area being studied is 20 miles south of the Canadian border in northwestern Montana. The 80-acre study site is situated 0.3 miles south of Logging Creek Ranger Station, just north of the North Fork Road in Glacier Park, MT (Stand No. 1 in Lunan and Habeck 1973). Elevation is about 3,500 feet. Terrain is nearly level with a 2 to 5 percent slope to the southwest. The site is bounded by Sullivan Meadow on the northeast. The exact boundaries of the prescribed burn were selected based on minimum need

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Table 1.--Changes in mean numbers of trees per acre and relative species density in different size classes before and 1 year after burning on burn plots

Size classes and species	Before		After	
	No./Acre	Rel. density	No./Acre	Rel. density
		Percent		Percent
Mature trees (more than 6 inches d.b.h.)				
Douglas-fir	43	35.8	43	44.8
Spruce	37	30.8	23	24.0
Lodgepole pine	11	9.2	3	3.1
Ponderosa pine	14	11.7	14	14.6
Western larch	13	10.8	12	12.5
Subalpine fir	2	1.7	1	1.0
Subtotal	120	100.0	96	100.0
Saplings (less than 6 inches d.b.h., but more than 4.5 feet tall)				
Douglas-fir	93	23.2	49	32.5
Spruce	160	39.9	55	36.4
Lodgepole pine	103	25.7	26	17.2
Ponderosa pine	--	--	--	--
Western larch	29	7.2	11	7.3
Subalpine fir	16	4.0	10	6.6
Subtotal	401	100.0	151	100.0
Seedlings (less than 4.5 feet tall)				
Douglas-fir	2,056	82.0	741	38.7
Spruce	353	14.1	212	11.1
Lodgepole pine	70	2.8	953	49.7
Ponderosa pine	9	0.4	--	--
Western larch	--	--	--	--
Subalpine fir	18	0.7	9	0.5
Subtotal	2,506	100.0	1,915	100.0
Totals - All size classes				
Douglas-fir	2,192	72.4	832	38.5
Spruce	550	18.2	290	13.4
Lodgepole pine	184	6.0	982	45.5
Ponderosa pine	23	0.8	14	0.6
Western larch	42	1.4	23	1.1
Subalpine fir	36	1.2	20	0.9
Grand totals	3,027	100.0	2,161	100.0

for firelines so that environmental impact was minimized (Wakimoto 1984).

Vegetation

The study area would be considered a spruce/*Clintonia* habitat type (Wakimoto 1984), and involves various elements of three Society of American Foresters cover types (Burns 1983): interior Douglas-fir (210), interior ponderosa pine (237), and lodgepole pine (218). Six tree species were found in the study area. Douglas-fir (*Pseudotsuga menziesii*), spruce (*Picea glauca* X *P. engelmannii*), and lodgepole pine (*Pinus contorta*) tend to dominate (tables 1 and 2). In addition, ponderosa pine (*Pinus ponderosa*) was found in stands with well-drained southwesterly aspects and subalpine fir (*Abies lasiocarpa*) on more moist and cooler sites. Western larch (*Larix occidentalis*) was distributed more broadly where previous fires have created suitable seedbed conditions. A 1-acre unit near the southern boundary of the 80-acre study site presented a different situation: it contained a solid stand of single-age lodgepole pine that originated after a small spot fire in 1926. The following primary understory species were found on the 21 study plots:

Shrubs

Amelanchier alnifolia
Rosa spp.
Rubus parviflorus
Salix spp.
Spirea betulifolia
Symphoricarpos albus
Vaccinium spp.

Subshrubs

Arctostaphylos uva-ursi
Chimaphila umbellata
Linnaea borealis

Grass

Calamagrostis rubescens

Forbs

Arnica cordifolia
Clintonia uniflora
Cornus canadensis
Epilobium angustifolium
Epilobium watsonii
Fragaria virginiana
Lathyrus ochroleucus
Osmorhiza chilensis
Thalictrum occidentale

A total of more than 80 species are found in the 80-acre study area.

Table 2.--Control plot data on mean numbers of trees per acre, 1982-1984

Size classes and species	Before		After	
	No./Acre	Rel. density	No./Acre	Rel. density
		Percent		Percent
Mature trees (more than 6 inches d.b.h.)				
Douglas-fir	5	4.2	5	4.4
Spruce	4	3.3	4	3.5
Lodgepole pine	77	64.2	70	62.0
Ponderosa pine	22	18.3	22	19.5
Western larch	12	10.0	12	10.6
Subalpine fir	--	--	--	--
Subtotal	120	100.0	113	100.0
Saplings (less than 6 inches d.b.h., but more than 4.5 feet tall)				
Douglas-fir	0	--	--	--
Spruce	59	44.0	54	40.9
Lodgepole pine	65	48.5	70	53.0
Ponderosa pine	0	--	0	--
Western larch	10	7.5	8	6.1
Subalpine fir	--	--	--	--
Subtotal	134	100.0	132	100.0
Seedlings (less than 4.5 feet tall)				
Douglas-fir	2,137	90.5	2,212	92.2
Spruce	112	4.7	112	4.7
Lodgepole pine	--	--	--	--
Ponderosa pine	113	4.8	75	3.1
Western larch	--	--	--	--
Subalpine fir	--	--	--	--
Subtotal	2,362	100.0	2,399	100.0
Totals - All size classes				
Douglas-fir	2,142	81.9	2,217	83.8
Spruce	175	6.7	170	6.4
Lodgepole pine	142	5.4	140	5.3
Ponderosa pine	135	5.2	97	3.7
Western larch	22	0.8	20	0.8
Subalpine fir	--	--	--	--
Grand totals	2,616	100.0	2,644	100.0

Weather

Weather records for the past 50 years at Polebridge, 8 miles to the northwest, show a record low temperature of -46 °F and a high of 102 °F. Over the past 30 years, July has been the warmest month, with a mean maximum of 80 °F and a mean minimum of 41 °F. Temperatures in August 1983, just before the burn, ranged from 40 to 91 °F. Relative humidity varied from a low of 22 percent to a typical nighttime recovery of 100 percent. The daily mean low was 35 percent.

Fire History

A fire history study carried out in 1982 and 1983 concluded that fire in this forest has a mean interval of about 26 years (Barrett 1983). The longest fire-free time period between 1600 and the present was the past 68 years.

METHODS

Seventeen circular 1/10-acre experimental plots were laid out systematically across the 80-acre prescribed burn area, with four control plots in adjacent similar forest types. Fifteen of the experimental plots and three of the control plots were placed in vegetation where young Douglas-fir, spruce, and some subalpine fir were coming in under an overstory of ponderosa pine, western larch, and some Douglas-fir. The other two experimental plots and one control plot were placed in the 1-acre lodgepole pine stand to determine how prescribed fire would modify this very different vegetation type. All trees on these plots more than 4.5 feet tall were recorded by species and size classes.

On each 1/10-acre plot, two 1/300-acre subplots, two 1/1000-acre subplots, and four 19.7- by 19.7-inch subplots were established for sampling trees less than 4.5-feet tall, cover and frequency of shrubs, and cover and frequency of herbaceous plants, respectively. Twelve additional measurements were made:

1. Percent cover of mineral soil, rock, moss-lichen, litter, and total grass and forbs in the 84 herbaceous subplots.
2. Down woody fuel level, using Brown's (1974) line intercept technique.
3. Impact of the prescribed burn on mature ponderosa pine, by marking 32 individuals with metal tags, and collecting data on diameter and special fuel characteristics. Of particular concern were aerial (ladder) fuels near or beneath the canopy of the individual pine, and special accumulation of large fuels (particularly those greater than 6 inches diameter), and depth of duff at the base of each tree. Postburn observations and measurements included percentage of crown scorch and severity of bole scorch (Ryan 1982), whether ladder fuels burned, what percentage of the bole showed insect pitch tubes, and the general appearance of the tree.
4. Depth of duff consumed by the fire at each of the individual trees, by placing duff pins at 1-, 2-, 3-, 5-, and 7-foot distances in the four cardinal directions around 20 ponderosa pines.
5. Preliminary indications of the effect of duff consumption on damage to cambial tissue of the pine, by collecting increment core samples at the ground line on 19 of the 20 pines, 11 months after the fire (one pine did not burn). Four samples were taken from each tree at the point of intersection of duff pin transects with the tree bole. Samples were treated with a chemical that determines the presence of peroxidase--an indication of living cambium (Ryan 1982).
6. Indication of the temperature level and duration during the fire, by placing thermocouples at various levels in the duff and soil around two additional mature pines (Ryan and Frandsen, in preparation).
7. Shrub production, by placing plots around 20 individual serviceberry and willow plants to determine the impact of the burn on these high-potential wildlife browse species. Measurements of the diameters of twigs at the base of current growth were then converted by formula (Wright and others 1982) to oven dried weight.
8. Deer and elk use of the burn area by counting pellet groups before and after burning in 32 1/300-acre plots.
9. Fuel moisture by gathering samples from upper and lower duff, litter, fine dead fuels (less than 1/4 inch), and various species of living forbs and grasses as they dried out during the month of August leading up to the burn date.
10. Temperature, humidity, precipitation, and fuel moisture by setting up a field weather station early in the summer near the burn site. A Remote Automatic Weather Station (RAWS) was set up 10 days before burn time to monitor weather conditions as they neared prescription without an observer needing to be on site daily. A standard fire weather kit was also used during the burn, together with 10-hour fuel sticks and fuel moisture probes.
11. Photographs in black and white and color taken from the center point of each plot looking north, east, south, and west before and after the burn, to show visual differences in vegetative appearance on the plots.
12. Photographs taken during the burn to document burning conditions, including typical flame lengths involved in the ponderosa pine and spruce-fir vegetation as contrasted with those found in the lodgepole pine vegetation.

RESULTS

Ignition/Burn Conditions

The prescription in the burn plan called for a fall season burn, with ignition at midday. It also called for temperatures between 75 and 80 °F and relative humidities between 20 and 50 percent with 30 percent preferred. Winds of 2 to 10 mi/h from the southeast, south, southwest, or west were desired.

Ignition began at 1:30 p.m. on August 30, 1983; burning was largely completed on August 31. Temperatures during the first afternoon reached 85 °F and the relative humidity dropped below 20 percent. Wind was not a factor. Because the ignition pattern was by strip head fires, fire behavior was modified somewhat by interaction between strips; nevertheless, flame lengths of 1 foot and rates of spread from 1 to 3 feet per minute were common in ponderosa pine needle and litter areas. The burning was spotty, tending to focus on areas of fuel concentrations or heavy duff layers, occasionally torching out through the tops of individual spruce.

Burning conditions the second day were similar to the first. However, the lodgepole pine plot was burned that day, with more spectacular results for flame lengths and rates of spread (fig. 1). Flame lengths of 25 feet were common; some flames reached 10 feet above the tops of the 45-foot lodgepole pines. The total burning time for the 1-acre unit was about 10 minutes. Despite this behavior, no control problems developed.

Figure 1.--Flame lengths of 25 feet or more were found briefly on the small lodgepole pine plot. No control problems developed because different, less flammable fuels surrounded this unit.

Fuel moistures at the time of the burn varied from 9 to 16 percent for litter and from 21 to 97 percent for duff. Median duff readings were about 36 percent.

Thermocouple measurements in smoldering duff at the root collars of the two instrumented trees indicated temperatures near 582 °F (300 °C) for 5 to 6 hours and above 842 °F (450 °C) for about 30 minutes. Sampling of cambial tissue on each of these trees gave a total reading of nine dead samples (Ryan and Frandsen, in preparation) and one living.

Impact on Vegetation

Numbers of larger (more than 6 inches d.b.h.) Douglas-fir, ponderosa pine, and western larch on the plots remained unchanged 1 year following the burn, but their relative densities increased (table 1). By contrast, numbers of larger spruce decreased by more than one-third and numbers of larger lodgepole pine decreased by more than two thirds. Relative densities of these latter two species also substantially decreased.

Saplings of all species (less than 6 inches d.b.h. but more than 4.5 feet tall) decreased by an average of more than 62 percent (fig. 2). Total numbers of seedling conifers (less than 4.5 feet tall) decreased by 23 percent. However, numbers of Douglas-fir and spruce seedlings decreased by 60 percent, while lodgepole pine seedlings--primarily on study plots 13 and 14--increased by more than 12 times from 70 to 953 per acre. Looking specifically at the intensely burned lodgepole pine plots (fig. 3), the increase was from 225 to more than 7,800 per acre or a 34-fold increase. The relative percentage of Douglas-fir seedlings dropped by more than 50 percent, while lodgepole pine seedlings increased from 3 to 50 percent of the total seedling numbers.

Numbers and relative density of all species and age classes of trees remained relatively constant

Figure 2.--On most of the 80-acre study area, the understory burn killed 60 percent of the sapling Douglas-fir and spruce with little damage to overstory pine and larch. A, Study plot 2 before burning (1982). B, The same site after burning (1984).

Figure 3.--In a special 1-acre unit of primarily single-age lodgepole pine, all trees were killed by more intense, stand-replacing fire behavior. A, Study plot 13 before burning (1982). B, The same site after burning (1984). Large numbers of lodgepole pine seedlings are coming in here now.

on control plots (table 2), confirming that fire (and not other environmental factors) was primary in bringing about the observed changes.

A small control plot sample (four plots) and a lack of exact repeatability of the shrub and herb sampling system by different crews precluded the opportunity to quantitatively evaluate shrub/ herb changes. Generally, total shrub cover was about 20 percent on the plots, with seven species dominating. Fire did not cause a major increase or decrease in most such shrubs, although Spiraea betulifolia appears to respond favorably to fire. Spiraea was the most frequent shrub, with a mean of 90 percent. Rosa spp. (rose) followed with about 67 percent. Neither was impacted adversely by fire. Rubus parviflorus (thimbleberry) coverage equalled these two species based on very heavy appearance in a few plots, but it did not occur as frequently as the others. Vaccinium spp. was found in more than 40 percent of the microplots, but its average coverage was small.

The low-growing subshrubs, Arctostaphylos uva-ursi and Linnaea borealis, which have surface stems, showed signs of decreased coverage and frequency following burning. Two species of Epilobium (fireweed) came in following burning while almost none were found on control plots. In general, burning tended to reduce the coverage and frequency of forbs and subshrubs somewhat during this first year after burning, although none were lost completely.

Wildlife Browse Shrubs

Willow and serviceberry were severely browsed and decadent prior to burning, and hence could not respond vigorously to the prescribed fire treatment. Preliminary analysis of shrub production data for these two species indicates that while certain individuals were stimulated to greater production by one set of conditions, others were killed by fire. We will be able to say more about this after another year or two of postburn measurements. The first year's estimate of ungulate use (based on pellet groups) showed no change following burning.

Mineral Soil

Mineral soil increased slightly after burning, and only in small areas. Litter coverage remained about constant, even though much was

Table 3.--Down woody fuels before and after prescribed burn (in tons/acre)

Fuel size class	Preburn total	Postburn		
		Preburn remaining	Newly fallen after fire	Postburn total
0-0.25 inch	0.33	0.11	0.25	0.35
0.25-1 inch	.5	.2	.2	.4
1-3 inches	1.4	.7	.2	.9
3+ inches sound	16.9	8.7	1.8	10.4
3+ inches sound and rotten	23.5	14.5	2.3	16.3
Total woody	25.7	15.5	2.9	17.9
Mean duff depth (inches)	2.2	0.8	--	0.8

burned, because burned litter was replaced by fresh needle cast and small twigs from scorched trees.

Fuels

Down woody fuels found prior to burning were reduced from more than 25 to about 15 tons per acre or about 40 percent by the fire (table 3). Mean duff depths were reduced more than 60 percent (fig. 4). However, the fire also killed small Douglas-fir, spruce, and other saplings and led to an addition of nearly 3 tons per acre of newly fallen materials, resulting in a net reduction of only 30 percent in down woody fuels.

Figure 4.--Depths of duff burned near the base of one large ponderosa pine were measured on duff pins placed prior to burning. Technician is measuring nearly 10-inch depth at the point near his clipboard.

Impacts on Mature Ponderosa Pine

Analysis of the impact of fire on the 32 mature ponderosa pine revealed that all but four showed 100 percent bark char at the base of the tree, with heights of char ranging from 6 inches to 10 feet or more. Yet only one pine had substantial crown scorch. One year after the burn, using Ryan's (1982) index of severity, half of the trees showed only light bark char, while the other half showed a mixture of light to medium severity bark char or light to severe bark char on parts of the bole. Even 2 years after the burn, only two of the 32 trees appeared likely to die.

In sampling cambium on 19 trees, Ryan and Frandsen (in preparation) found at least three of the four samples living on 50 percent of the trees. The remaining 10 trees were nearly equally distributed between 50 percent living, 25 percent living, and all dead categories. Eight had insect pitch tubes showing on at least 5 percent of the circumference of the tree. Only three had pitch tubes on more than 30 percent. Despite the cambium sample and pitch tube evidence, 18 of the 20 trees still appeared healthy 2 years after the burn.

When an analysis was made of the depth of the duff burned in a given aspect, compared with the condition of the cambium, it appeared that areas of dead cambium tend to be associated with areas of deeper burned duff (table 4). No statistical tests, however, can be applied to these data. In addition, it appears that cambium samples from older ponderosa pines (between 32 and 40 inches d.b.h.) are more likely to be dead than samples from younger pines (between 24 and 30 inches d.b.h.).

DISCUSSION

Our results indicate that wilderness managers can use understory burning effectively in pine-fir-larch forests in the Northern Rockies to reduce down woody fuels and remove understory conifers without damaging mature overstory trees and without control problems. This particular burn fell somewhat short of meeting the management objective of reducing down woody fuels by more than 50 percent. Drier fuels might have accomplished this, but as noted under the results section, when saplings are killed--another objective--they provide additional down woody materials. It appears that a series of two or more burns may be needed to reduce down woody fuels and to move toward what may be more natural (presuppression) fuel levels.

The burn killed about 60 percent of understory conifers. In so doing, it killed understory that germinated between 1918 and 1953--a period of active fire suppression. To that extent, it would appear to have moved in the direction of restoring a more natural stand structure. The burn also avoided more than 50 percent crown scorch on most ponderosa pine, and to date has caused little mortality to the mature age class. There could be a delayed reaction, with trees dying 3 to 5 years following the fire--or instead, there may be adequate living cambial tissues in areas not sampled in the bole.

Little mineral soil was exposed, except on the intensely burned lodgepole pine site. In that area, germination of many lodgepole pine seedlings was stimulated by the fire. No ponderosa pine seedlings were found on the study plots, either because of lack of viable seeds at the time of the burn or lack of mineral soil seedbed at the right locations. It remains to be seen whether the fire will result in a rejuvenated successional cycle of shrubs, forbs, and grasses.

Our results confirm the contention by Lunan and Habeck (1973) that ponderosa pine is not reproducing well in these stands in the North Fork. Both numbers and relative density of ponderosa pine and larch in earlier Logging Creek forests were greater than those that have germinated and survived as saplings and seedlings during the past 40 to 70 years. Increment core samples of 49 ponderosa pine in the sapling age class found on more favorable sites in the North Fork area south of Logging Creek to Anaconda Creek ranged in age from 34 to 87 years, with a median age of 57 years. No pines in this age class were found

Table 4.--Depths of burned duff compared with mortality measurements of ponderosa pine cambium[1]

Living cambium				Dead cambium			
No. samples	Aspect	Burned duff depth[2] X	Range	No. samples	Aspect	Burned duff depth X	Range
		---Millimeters---				---Millimeters---	
11	North	136.8	0 - 220	8	North	152.5	85 - 330
6	East	140.8	75 - 295	13	East	186.5	90 - 315
13	South	149.6	35 - 280	6	South	188.3	85 - 280
12	West	103.2	30 - 175	7	West	212.9	150 - 260
Totals:							
42		131.7	0 - 295	34		184.3	85 - 330

[1]Determinations of living and dead cambium were made on 19 trees by Kevin Ryan on July 25, 1984, 1 year after the prescribed burn (see text for details).
[2]Duff depths were those measured on the duff pin located 1 foot from the base of the mature ponderosa pine, on the aspect nearest to each cambium sample.

in the study plots and few were found anywhere in the 80 acre burn area.

More than 80 percent of these 49 saplings became established between 1914 and 1942, perhaps as part of the immediate invasion after initiation of fire suppression. Studies of the nearby Agassiz Glacier (Carrara and McGimsey 1981) also show this to have been a period of above-average summer temperatures and decreased precipitation in the North Fork area; these factors would tend to favor ponderosa pine over competitors. Corroborating evidence of drought conditions comes from studies of western white pine (Pinus monticola) tree rings in northern Idaho, where Leaphart and Stage (1971) concluded that the most adverse growth conditions in the past 280 years with regard to intensity and duration of dry and hot weather impacts on growth occurred from 1916 to 1940.

In future research and monitoring of fire effects on shrubs and forbs, great care needs to be taken to standardize (a) numbers of sample plots, (b) criteria for distinguishing cover classes, and (c) application of these criteria by crews that may change from year to year. Ideally, the same personnel will read cover plots through a complete sampling sequence. Continuity in crew leaders is highly important.

CONCLUSIONS

In summary, the fire was a success in allowing Glacier National Park resource managers to initiate an understory burning program--with some knowledge of impacts related to management objectives. A program by National Park Service staff for monitoring further changes in fuel and forest structure at this and other prescribed burns in Glacier National Park could determine whether more such burns would be helpful in the boundary zone of the North Fork Flathead River basin, or whether the National Park Service might simply prefer to let "natural" lightning-caused fires burn in these zones. Concern by neighboring landowners as well as agency concern about possible high-intensity, stand-replacing fires near the boundary may determine that a continuation of such understory burning would be advisable. If so, the objective would be to restore more of a mosaic pattern to various fuels--including understory sapling conifers--than presently exists. This would avoid an unnaturally continuous layer of young conifers that could lead to widespread, high intensity burning along the boundary zone, perhaps an unacceptable outcome at this time.

REFERENCES

Barrett, S. W. Fire history of Glacier National Park: North Fork Flathead River Drainage. 1983. Unpublished Final Report on file at: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Intermountain Fire Sciences Laboratory, Missoula, MT.

Biswell, H. H. The use of fire in wildland management in California. In: Natural Resources: Quality and Quantity. Berkeley, CA: University of California Press; 1967: 71-87.

Brown, J. K. Handbook for inventorying downed woody material. General Technical Report INT-16. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1974. 24 p.

Burns, R. M. Silvicultural systems for the major forest types of the United States. Agriculture Handbook No. 445. Washington, DC: U.S. Department of Agriculture, Forest Service; 1983. 191 p.

Carrara, P. E.; McGimsey, R. G. The late-neoglacial histories of the Agassiz and Jackson Glaciers, Glacier National Park, Montana. Artic and Alpine Research. 13(2): 183-196; 1981.

Habeck, J. R.; Mutch, R. W. Fire-dependent forests in the Northern Rocky Mountain. Quaternary Research. 3: 408-424; 1973.

Hartesveldt, R. J.; Harvey, H. T. The fire ecology of sequoia regeneration. In: Proceedings Tall Timbers Fire Ecology Conference No. 7; 1967 November 9-10; Lake County, CA. Tallahassee, FL: Tall Timbers Research Station; 1967: 65-77.

Kilgore, B. M. Impact of prescribed burning on a sequoia-mixed conifer forest. In: Proceedings Tall Timbers Fire Ecology Conference No. 12; 1972 June 8-9; Lubbock, TX. Tallahassee, FL: Tall Timbers Research Station; 1973: 345-375.

Kilgore, B. M. Fire management programs in parks and wilderness. In: Lotan, James E.; ed. Fire-its field effects: Proceedings of the symposium; 1982 October 19-21; Jackson, WY. Missoula, MT: International Fire Council; Pierre, SD: Rocky Mountain Fire Council; 1982: 61-91.

Komarek, E. V. Fire and animal behavior. In: Proceedings Tall Timbers Fire Ecology Conference No. 9; 1969 April 10-11; Tallahassee, FL. Tallahassee, FL: Tall Timbers Research Station; 1969: 161-107.

Leaphart, C. D.; Stage, A. R. Climate: a factor in the origin of the pole blight disease of Pinus monticola Dougl. Ecology. 52(2): 229-239; 1971.

Lunan, J. S.; Habeck, J. R. The effects of fire exclusion on ponderosa pine communities in Glacier National Park. Canadian Journal of Forest Research. 3: 574-579; 1973.

Ryan, K. C. Techniques for assessing fire damage to trees. In: Lotan, James E.; ed. Fire-its field effects: Proceedings of the symposium; 1982 October 19-21; Jackson, WY. Missoula, MT: Intermountain Fire Council; Pierre, SD: Rocky Mountain Fire Council; 1982: 1-11.

Ryan, K. C.; Frandsen, W. H. Effects of ground fire on old-growth ponderosa pine. In preparation.

Wakimoto, R. H. Current fire management research in Glacier National Park. Western Wildlands. 10(3): 20-25; 1984.

Weaver, Harold. Fire as an ecological and silvicultural factor in the ponderosa pine region of the Pacific slope. Journal of Forestry. 41: 7-15; 1943.

Wright, R. G.; Jenkins, K.; Butterfield, B.; Key, C.; Happe, P. Wildlife habitats in riparian zones of the North Fork and Mainstem Flathead River, Montana. Moscow, ID: University of Idaho, National Park Service Cooperative Park Studies Unit; 1982. 192 p.

A NONDESTRUCTIVE METHOD FOR DATING LIVING, FIRE-SCARRED TREES IN WILDERNESS AREAS

Paul R. Sheppard and James P. Lassoie

ABSTRACT: The purpose of this study was to directly compare the coring and wedging methods used to date living, fire-scarred trees in wilderness areas. One wedge and at least two increment cores were extracted from each of several single-scarred Pinus contorta (Dougl. ex Loud) trees at three different sites, and the prescar growth of each extraction was cross-dated. Fire dates from extractions of the same tree were directly compared and were equal when both the cores and the wedge were dated. The method of coring through the scar to the pith and then cross-dating the prescar growth is adequate for dating single-scarred trees, but not for multiple-scarred trees. This method should be attempted within wilderness and other natural areas instead of wedging and sectioning.

INTRODUCTION

The use of increment cores from living, fire-scarred trees to date fires has been criticized as being inaccurate (Cwynar 1977). Stokes (1980) implied that cores are not adequate for dating fires because cross-dating must be done along a radius that is away from the scar to avoid rings that are distorted by the fire. The criticism was justified because cores were often incorrectly analyzed by merely counting growth rings from the bark to the scar, instead of using dendrochronological techniques (Stokes and Smiley 1968) to date the scar accurately.

To avoid inaccurate fire dates from cores, extracting wedge sections from the scar face, or even taking whole cross-sections of scarred trees, has been suggested (McBride and Laven 1976; Arno and Sneck 1977). Many investigators, however, have only counted the rings from the bark to the scar, and thus have not gained much more information than they would from properly positioned cores. Madany and West (1980) used the wedge dating method of Arno and Sneck (1977), which included counting rings and then adjusting the fire dates to create a composite fire index. Later, Madany and others (1982) reanalyzed these wedges by cross-dating them with a master tree-ring chronology for that area. They reported fire dates different from their first analysis and concluded that the second dates were more accurate. Therefore, cross-dating must be done for wedging to be an accurate method of dating fires (Stokes 1980).

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Some researchers claim that wedging is not unduly harmful to the sampled tree. McBride and Laven (1976) reported removing only 5 percent of the circumference, while Arno (1976) estimated that 10 percent of the basal area was removed from trees by wedging. Madany and others (1982) stated that wedging was generally nondestructive to the tree, but also concluded that in some cases its impact may preclude or limit its use. Scars, however, can be set deeply into the callus growth, and wedging such trees to sample the scar would clearly weaken the stem. In areas where trees are protected by legislative mandate, such as designated state and federal wilderness and other natural areas, destructive sampling may be forbidden by the management or judged inappropriate by researchers.

Regardless of past criticism, coring is clearly less destructive than wedging and is preferable over wedging if accurately performed. Swetnam (1984) successfully used coring to date scars that formed after native Americans peeled off bark for food.

The objective of this study was to determine if the coring method could date fire scars as accurately as the more destructive wedging method. For this, we directly compared the fire dates obtained from coring and cross-dating of prescar growth to those dates obtained from wedging the same single-scarred Pinus contorta trees.

METHODS

Increment cores and wedges were extracted from several lodgepole pine trees at three locations, all of which were above 9000 ft elevation. Ten Pinus contorta var. murrayana (Grev. & Balf.) Engelm. trees were sampled in southern California from the Mount San Jacinto State Park Wilderness, along with four from the Sugarloaf Mountain Roadless Area (fig. 1a). Five Pinus contorta (Balf.) var. latifolia (stat. nov.) trees were sampled in the Medicine Bow Mountains of southeastern Wyoming (fig. 1b). At least one core was extracted from each side of the scar. The borer was positioned low on the stem (Zackrisson 1980) and directed so that the cores were away from the scar face, passed through the pitch deposit or structural break, and contained prescar growth (fig. 2, core C). Occasionally two or three attempts were necessary to extract the properly positioned core because of rotten wood, resin pockets, or improper boring direction. Wedges

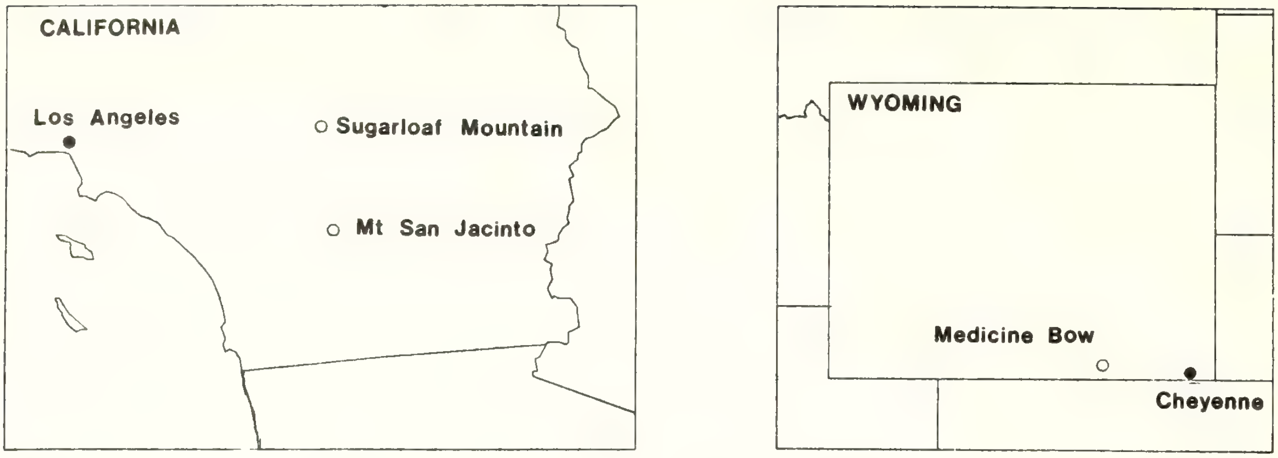

Figure 1.--Maps of (a) southern California and (b) Wyoming. Closed dots are principal cities and open circles are the study sites.

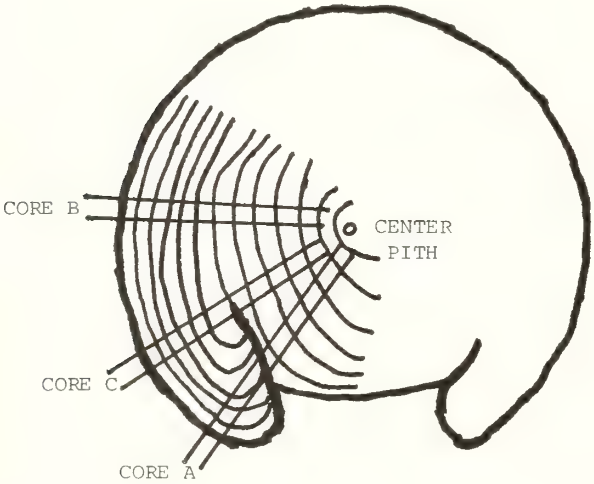

Figure 2.--Cross-section view of a scarred tree showing increment borer positions. Core A is too close to the open wood face; core B is too far from the face. Core C is the correct position.

were extracted following techniques described by Arno and Sneck (1977). All samples were sanded to a fine surface. Prescar ring growth patterns on the cores and wedges were dated, independent of each other, using standard dendrochronological techniques (Stokes and Smiley 1968).

A skeleton plot technique (Stokes and Smiley 1968) was used to date the prescar growth against appropriate master tree-ring chronologies (table 1) obtained from the Laboratory of Tree-Ring Research, University of Arizona, Tucson (Drew 1972, 1975). Prescar growth was not distorted by the fire, satisfying Stokes' (1980) concern. Although some ring anomalies existed in prescar growth as a result of climatic effects, cross-dating usually was successful in accounting for them. Postscar growth, however, had ring anomalies due to the fire disturbance in addition to those due to climate, making cross-dating more difficult. Postscar growth was still counted to approximate the fire date. It was assumed that this count underestimated the actual number of years since the fire, because missing rings are probably more prevalent than false or extra rings in trees at high elevations (Fritts and others 1965). The postscar count was useful as a starting point for matching the skeleton plots to the chronologies. The final dates were checked by another dendrochronologist at the Tree-Ring Lab at Lamont-Doherty Geological Observatory, Palisades, NY.

RESULTS

For 12 of the 19 sampled trees, both the cores and the wedge from each tree were dated successfully. The core and wedge dates for each of these 12 scars were equal (table 2). Of the cores and wedges that were not dated, only one scar (from Mount San Jacinto) was undated because its growth was too severely suppressed to date either the cores or wedge. Two other scars from Mount San Jacinto were dated by wedges but not by the cores because insufficient

Table 1.--Tree-ring chronologies used to cross-date cores and wedges. The tree species used in the construction of each chronology is shown

Location	Chronology	Species
Mount San Jacinto, CA	Keen Camp Summit	Pseudotsuga macrocarpa (Vasey) Mayr
Sugarloaf Mountain, CA	Baldwin Lake South	Pinus jeffreyi Grev. & Balf.
Medicine Bow Mountains, WY	Laramie A	Pseudotsuga menziesii var. glauca (Beissn.) Franco

Table 2.--Fire dates from all dated scars

Sample	Location[1]	Core date	Wedge date	Date based on post-scar count
1	MTSJ	1773	1773	1774
2	MTSJ	1798	1798	1809
3	MTSJ	1777	1777	1783
4	MTSJ	1798	1798	1811
5	MTSJ	1817	1817	1824
6	MTSJ	1893	1893	1904
7	MTSJ	1933	1933	1933
8	SMRA	1887	1887	1894
9	SMRA	1910	1910	1914
10	MBMT	1867	1867	1876
11	MBMT	1909	1909	1914
12	MBMT	1880	1880	1881

[1]MTSJ = Mount San Jacinto State Park, CA
SMRA = Sugarloaf Mountain Roadless Area, CA
MBMT = Medicine Bow Mountains, WY

prescar growth was extracted to date the fires accurately. Four other samples (two each from the Sugarloaf and Medicine Bow sites) were not dated because the trees were scarred at an early age, leaving insufficient prescar growth for accurate cross-dating. In most cases, the fire dates from postscar ring counting were more recent than the core and wedge dates.

DISCUSSION

Although the sample size of successful cases was small, coring single-scarred trees and cross-dating the prescar growth of the cores provided the same fire dates as those obtained from wedges. It is important, however, that the maximum available prescar growth be extracted with each core, for prescar growth is easier to cross-date than postscar growth. With trees that are sensitive to climate, at least 50 years of prescar growth should be extracted. More prescar growth is necessary with trees that have low sensitivity to climate and show complacent ring patterns.

This method of coring and cross-dating is not adequate for dating multiple-scarred trees because the increment borer cannot be positioned correctly to sample each scar (fig. 2). Wedges or sections are required in these cases. High-elevation forested ecosystems, however, often have fire regimes of infrequent, low-intensity fires (Kilgore 1981) that tend to leave living, single-scarred trees. Because these ecosystems are typical of many designated wilderness areas (Hendee and others 1978), researchers investigating these fire regimes should attempt coring and cross-dating of prescar growth before resorting to the more destructive wedge method.

Master tree-ring chronologies exist for various species in many forested areas of both the western and eastern United States. It would be preferable, however, to collect cores from old-aged, undisturbed trees on the study site in order to construct a species and site specific chronology (Fritts 1976). Cross-dating is easier with a specific chronology that reflects local climate than with a regional chronology that may reflect a slightly different climate.

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REFERENCES

Arno, S. F. The historical role of fire on the Bitterroot Natural Forest, Research Paper INT-18. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1976. 29 p.

Arno, S. F.; Sneck, K. M. A method for determining fire history on coniferous forests of the Mountain West. General Technical Report INT-42, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 28 p.

Cwynar, L. C. The recent fire history of Barron Township, Algonquin Park. Canadian Journal of Botany. 55: 1524-1538; 1977.

Drew, L. G. Tree-ring chronologies of western America. III. California and Nevada. Tucson, AZ: University of Arizona Laboratory of Tree-Ring Research; 1972. 38 p.

Drew, L. G. Tree-ring chronologies of western America. V. Washington, Oregon, Idaho, Montana, and Wyoming. Tucson, AZ: University of Arizona Laboratory of Tree-Ring Research; 1975. 45 p.

Fritts, H. C. Tree rings and climate. New York: Academic Press; 1976. 567 p.

Fritts, H. C.; Smith, D. G.; Cardis, J. W.; Budelsky, C. A. Tree-ring characteristics along a vegetation gradient in northern Arizona. Ecology. 46(4): 393-401; 1965.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Miscellaneous Publication Number 1365. Washington, DC: U.S. Department of of Agriculture, Forest Service; 1978. 381 p.

Kilgore, B. M. Fire in ecosystem distribution and structure: western forests and scrublands. In: Proceedings, fire regimes and ecosystem properties; 1978 December 11-15; Honolulu, HI. General Technical Report WO-26. Washington, DC: U.S. Department of Agriculture, Forest Service; 1981: 58-89.

Madany, M. H.; Swetnam, T. W.; West, N.E. Comparison of two approaches for determining fire dates from tree scars. Forest Science. 28(4): 856-861; 1982.

Madany, M. H.; West, N. E. Fire history of two montane forest areas of Zion National Park. In: Proceedings, fire history workshop; 1980 October 20-24; Tucson, AZ. General Technical Report RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1980: 50-56.

McBride, J. R.; Laven, R. D. Scars as an indicator of fire frequency in the San Bernardino Mountains, California. Journal of Forestry. 74(4): 439-442; 1976.

Stokes, M. A. The dendrochronology of fire history. In: Proceedings, fire history workshop; 1980 October 20-24; Tucson, AZ. General Technical Report RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1980: 1-3.

Stokes, M. A.; Smiley, T. L. Tree-ring dating. Chicago: University of Chicago Press; 1968. 73 p.

Swetnam, T. W. Peeled ponderosa pine trees: a record of inner bark utilization by native Americans. Journal of Ethnobiology. 4(2): 177-190; 1984.

Zackrisson, O. Forest fire history: ecological significance and dating problems in the North Swedish boreal forest. In: Proceedings, fire history workshop, 1980 October 20-24; Tucson, AZ. General Technical Report RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1980: 120-125.

WILDERNESS FIRE ECONOMICS: THE FRANK CHURCH--RIVER OF NO RETURN WILDERNESS

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ABSTRACT: The objectives of this paper are to: (a) discuss the problems involved in an economic analysis for wilderness fire management, (b) compare the costs and area burned for four alternative fire management strategies, (c) describe how each strategy affects the risk of a catastrophic fire, and (d) discuss long-run ecological consequences and irreversible impacts. A cost/benefit analysis is used where expected burned area compared to the natural fire regimes is the measure of benefit. Decision analysis is used to compare the relative costs and area burned of four different fire management strategies: (1) Forest Service policy before 1978, where control was the only appropriate suppression response; (2) current policy prior to an approved plan, characterized by use of the Escaped Fire Situation Analysis (EFSA), where control, contain, and confine are appropriate suppression responses; (3) current policy augmented by an approved plan for unscheduled-ignition prescribed fires; and (4) current policy augmented by an approved plan for scheduled- and unscheduled-ignition prescribed fires. Strategy 1 resulted in costs of $421 per burned acre, strategy 2 in $118 per burned acre, strategy 3 in $52 per burned acre, and strategy 4 in $35 per burned acre.

INTRODUCTION

The Frank Church--River of No Return (FCRONR) Wilderness was established July 23, 1980, by Public Law 96-312. The area encompasses 2.35 million acres in central Idaho and is administered by six National Forests in two different Regions of the Forest Service. Special provisions were made in the act for mining, aircraft landings, grazing, small hydroelectric generators, and cultural resources. There are 74 parcels of non-federal land occupying 10,000 acres within the wilderness. In addition, 114 bridges in or adjacent to the wilderness and 58 administrative sites require protection. The Middle Fork and main Salmon are two of America's premier white water rivers, attracting some 8,000 floaters every year. There are 24 active airstrips with 4,400 aircraft landings each year. The FCRONR Wilderness includes a variety of environments from the steep, hot, dry, Salmon River Breaks country to cool, moist, high-elevation subalpine communities.

Fire management policy on National Forest System lands is to plan and execute fire management programs to minimize the program costs plus the net value change due to fire, consistent with land and resource management objectives (USDA Forest Service 1984). The purpose of this paper is to provide economic information to decision makers. The economic information is but one portion of the decision matrix. It assists in problem definition, in specification of objectives, and showing the economic tradeoffs associated with different decisions. The objectives of this paper are to:

1. Discuss the problems involved in an economic analysis of wilderness fire management.
2. Compare the costs and area burned for four alternative fire management strategies.
3. Describe how each strategy affects the risk of a catastrophic wildfire.
4. Discuss long-run ecological consequences and irreversible impacts.

WILDERNESS VALUE PROBLEM

Several economic techniques have been used to evaluate fire management programs (Baumgartner and Simard 1982; Gorte and Gorte 1979; Simard 1976). Most economic analyses of fire management programs today are based on minimizing cost-plus-net-value change. Quantifying change in wilderness resource value presents a major problem. A value can be attached to the set of goods and services that wilderness provides, for example: range, recreation, wildlife, water, mining, and structures (Condon 1985; Mills 1985). Yet, for the most part, these values are for nonconforming uses that are minor byproducts of wilderness and do not recognize wilderness as a resource by itself. Althaus and Mills (1982) use recreation visitor-days as the unit of measurement for value change in wilderness, but the wilderness resource is not synonymous with the recreation resource. The value of the wilderness resource to date has defied measurement.

Opportunity cost (the value foregone by investing in one resource instead of another) can be used to place a value on a good or service. A wilderness area must be worth at least as much as the value of the timber within it. However, opportunity cost always undervalues the resource. In addition, if a fire burns a part of a wilderness, the fire's effect on wilderness values is totally unrelated to the fire's effect on timber values (Chandler and others 1983).

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Table 1.--Summary of Frank Church--River of No Return fire occurrence (1960-83)

Cause	Size class A	B	C	D	E	F	G	Total	Percent
Lightning	1,491	296	44	5	2	5	2	1,845	88
Person	188	49	11	4	1	1	2	256	12
	1,679	345	55	9	3	6	4	2,101	

Because of these problems, very little has been written about wilderness fire management economics. Some exceptions are the economic analysis for the Lassen Fire Management Plan (Condon 1985), the economic analysis for the environmental assessment of the Gospel-Hump Wilderness fire management policy (Lukens and Saveland 1984), the economic discussion in the Selway-Bitterroot Wilderness fire management environmental impact statement (USDA Forest Service 1976), cost-effective fire management in national parks (Agee 1985), and criteria for evaluating the economic efficiency of fire management programs in park and wilderness areas (Mills 1985).

To circumvent the value problem, a cost/benefit analysis is used for this paper. The management objective for wilderness is to allow the forces of nature to operate unrestrained as much as possible. Plant communities require a certain amount of fire, just as they require a certain amount of precipitation. Thus, the average annual number of acres burned by fire is the measure of benefit. The closer the number of burned acres is to the historic (what fire history studies reveal) or "natural" condition, the greater the benefit. Altering the average annual burned area would be like altering the average annual rainfall.

DECISION ANALYSIS

Decision analysis is used to compare the relative costs and area burned for four different fire management strategies. Strategy 1 is the Forest Service policy before 1978, where control was the only appropriate suppression response. Strategy 2 is the current Forest Service policy prior to an approved plan, characterized by use of the Escaped Fire Situation Analysis (EFSA), where control, contain, and confine are appropriate suppression responses. Strategy 3 is the current policy augmented by an approved plan for unscheduled-ignition prescribed fires. Strategy 4 is the current policy augmented by an approved plan for unscheduled- and scheduled-ignition prescribed fires. The decision trees generate average annual costs and average annual acres burned. Most factors affecting wildland fire are extremely variable. Thus the absolute values generated have little utility as expected values, yet the relative values are useful for making comparisions that may aid decision making.

Decision analysis is a systematic approach for evaluating management alternatives when faced with uncertain future events. The decision trees readily show which variables are the most important in determining results. Decision analysis has been applied to several other problems in wildland fire management (Hirsch and others 1981; Radloff 1984; Seaver and others 1983). Decision trees for the four strategies are given in the appendix.

The first branch of the decision tree divides fires into lightning- and person-caused. Fire occurrence records for the period 1960-83 indicate that 88 percent of the fires in the FCRONR Wilderness are caused by lightning (table 1). The remaining 12 percent are person-caused fires. It is assumed that all person-caused fires will be considered wildfires and require appropriate suppression responses.

The lightning fire branch is divided into prescribed fire and wildfire. Strategies 1 and 2 do not have prescribed lightning fires. For strategies 3 and 4, a percentage of fires were presumed to have been allowed to burn under prescription. At the time of this analysis, prescriptions were still being developed. Historically, large fires in the FCRONR Wilderness occur during periods of high fire danger, a time when fires are most likely to be out of prescription. Thus more small size-class fires would meet prescribed fire criteria than large size-class fires. It is assumed that the judicious use of scheduled ignitions will create conditions that allow for more unscheduled-ignition prescribed fires.

For strategy 3, 30 percent of the class A, 15 percent of the class B, 5 percent of the class C, 2 percent of the class D/E, and 1 percent of the class F/G lightning fires were assumed to become prescription fires. When these percentages were applied to the fire occurrence record, a total of 27 percent of the lightning fires would be prescribed fires while 73 percent would be wildfires. For strategy 4, 40 percent of the class A, 25 percent of the class B, 10 percent of the class C, 4 percent of the class D/E, and 3 percent of the class F/G lightning fires were assumed to become prescription fires. When these percentages were applied to the fire occurrence record, a total of 37 percent of the lightning fires would be prescribed fires, while 63 percent would be wildfires.

For comparison purposes, the nearby Moose Creek District portion of the Selway-Bitterroot Wilderness has been functioning under an approved fire management plan since August 7, 1978. From 1978 through 1983, 48 of the 148 lightning fires, or 32 percent, have been unscheduled-ignition prescribed fires (Saveland and Hildner 1985). From July 1972 through 1983, 50 of 70 fires, or 72 percent, have been unscheduled-ignition prescribed fires on the Bitterroot National Forest portion of the Selway-Bitterroot Wilderness.

Probabilities of the different size-class fires for strategies 1 and 2 were determined from the fire occurrence record. For strategies 3 and 4, after the percent of prescribed fires was subtracted from the fire occurrence record, the remainder determined the probability distribution of the different size-class fires in the wildfire branch. The probabilities for the prescribed fire branch were subjectively estimated to be: class A - 70 percent, class B - 15 percent, class C - 11 percent, class D/E - 2 percent, class F/G - 2 percent.

The average size of the different size-class fires for strategy 1 was determined from fire occurrence records: class A - 0.1 acre, class B - 2 acres, class C - 32 acres, class D/E - 362 acres, class F/G - 10,047 acres. Due to the EFSA used in strategies 2, 3, and 4, it was assumed that the average size of class D/E fires would increase by a factor of 2 to an average size of 724 acres, and class F/G fires would increase by a factor of 1.5 to an average size of 15,070 acres. The average size of prescribed fires for strategies 3 and 4 were subjectively estimated: class A - 0.1 acre, class B - 2 acres, class C - 40 acres, class D/E - 750 acres, class F/G - 18,000 acres.

Each of the six National Forests that administer the FCRONR Wilderness submitted their average suppression costs by size class; these were then weighted according to their percentage of fires in each size class from the fire occurrence records. Wildfire expenditures only include variable costs associated with actual suppression activities. The fact that fixed costs such as presuppression and overhead are left out may bias the results toward the high-cost alternative if fire management productivity is held constant across all four alternatives. The costs for strategy 1 wildfires rounded to the nearest thousand and in 1984 dollars are: class A - \$2,000 per fire, class B - \$5,000 per fire, class C - \$37,000 per fire (based on \$1,156 per acre for average 32-acre fire), class D/E - \$298,000 per fire (based on \$797 per acre for average 362-acre fire), class F/G - \$3,466,000 per fire (based on \$345 per acre for average 10,047-acre fire). Compared to the results of Gonzalez-Caban and others (1984), these estimated costs may be conservative.

Strategies 2, 3, and 4 incorporate the change in costs due to the revised policy allowing appropriate suppression response and use of the EFSA. The per-acre costs are assumed to be reduced to \$100 per acre for class D/E fires and \$75 per acre for class F/G fires. For comparison purposes, costs on two escaped class E fires on the Bitterroot National Forest portion of the Selway-Bitterroot Wilderness were \$85 per acre.

Average costs of monitoring prescribed fires for strategies 3 and 4 were assumed to be \$250 per acre for A, B, and C class fires. This is the average cost of monitoring unscheduled-ignition prescribed fires on the Moose Creek Ranger District portion of the Selway-Bitterroot Wilderness. Condon (1985) arrived at a similar figure. Average costs for class D/E prescribed fires were subjectively estimated at \$1,000 per fire and class F/G fires at \$10,000 per fire.

Strategy 4 includes the use of scheduled-ignition prescribed fires in addition to the decision tree. Costs are assumed to be \$10 per acre. Most of the prescribed burning from scheduled ignitions is assumed to take place in ponderosa pine (Pinus ponderosa) community types. Similar burning conducted by the Bureau of Land Management and Challis National Forest has cost an average of \$10 per acre.

Decision analysis computes an expected burned area per fire and an expected cost per fire. It should be reemphasized that due to the above estimation procedures and extreme variability, absolute values have little utility as expected values, yet the relative values are useful for making comparisons. To give an idea of the variability involved, in the period from 1960 to 1983, the least expensive fire year was 1982 when 35 fires burned about 20 acres and cost about \$82,000. The worst year was 1979 when 123 fires burned a total of 77,000 acres, cost approximately \$27.4 million, and one firefighter was killed. The area can have even higher fire occurrence; 2,000 fires occurred in 3 days in 1940 in what were then the Idaho Primitive and Selway Wilderness Areas (Thompson 1964).

Table 2 compares the costs and area burned of the four different strategies. Also included in table 2 is an estimate of the historic (before suppression) average area burned per year. For the FCRONR Wilderness, it is assumed that the long-term average area burned per year is 1-2 percent of the total area. Of course there would be great variability from year to year. The area can be calculated by determining the number of acres of plant communities with a similar fire regime, dividing the number of acres by the fire cycle, and summing. For example, suppose an area consisted of 10,000 acres of ponderosa pine cycle of 15 years and 20,000 acres of western redcedar (Thuja plicata) with a fire cycle of 300 years. The historic average annual burned area would be:

$$\frac{10{,}000 \text{ acres}}{15 \text{ yr}} + \frac{20{,}000 \text{ acres}}{300 \text{ yr}} = 733 \text{ acres/yr}$$

$$\frac{733 \text{ acres/yr} \times 100\%}{30{,}000 \text{ acres}} = 2.4\%/\text{yr}$$

Table 2.--Relative cost comparison of four different fire management strategies and the resulting amount of area burned

	Avg. annual costs[1]	Costs per acre[2]	Avg. annual burned area[1]	Burned area as a percent of total area	Avg. annual costs per burned acre
	($/yr)	($/acre)	(acres/yr)	Percent	($/acre)
Historic (before suppression)			23,000–47,000	1-2	
Strategy 1 (fire policy prior to 1978)	1,951,354	0.83	4,640	0.20	421
Strategy 2 (current fire policy)	824,627	0.35	7,003	.30	118
Strategy 3 (unscheduled ignitions)	751,181	0.32	14,532	.62	52
Strategy 4 (unscheduled and scheduled ignitions)[3]	794,178	0.34	22,596	.96	35

[1]Based on mean of 87.54 fires per year.
[2]Based on 2,352,646 acres in the Frank Church--River of No Return Wilderness.
[3]Includes 5,000 acres burned each year by scheduled ignitions at $10 per acre.

Actual fire cycles have not been computed for the entire FCRONR Wilderness. For 235,000 acres of ponderosa pine-dominated communities along the Salmon River Breaks, the historic average annual burned area was calculated to be 12,256 acres per year (5 percent). For comparison, the adjacent Gospel-Hump Wilderness historic average annual burned area was calculated to be 2-3 percent per year and the adjacent Selway-Bitterroot Wilderness to be approximately 1 percent per year. If all lightning fires are allowed to burn in the decision tree (change lightning prescribed fire probability to 1.0 and wildfire probability to 0.0), the resulting area burned would be 334.19 acres per fire for 29,255 acres per year (1.2 percent).

Table 2 shows the tremendous cost savings that can be realized by effectively implementing the current fire policy and the Escaped Fire Situation Analysis (EFSA). Costs per acre are reduced by more then one-half, from $0.83 per acre of wilderness to $0.35 per acre of wilderness. This reflects the fact that large fires with a low probability of occurrence account for the bulk of average annual costs. The average cost per fire of large fires decreases as a result of not always having to commit large amounts of expensive suppression resources to remote areas. Savings can be realized by reducing the costs of large fire suppression through an appropriate suppression response and EFSA or by reducing the probability of large fire occurrence (Lukens and Saveland) 1984.

Strategy 4, the current policy augmented by unscheduled- and scheduled-ignition prescribed fires, comes closest to the historic level of average annual burned acres. Strategy 4 is the most economically efficient, costing $35 per burned acre. However, Strategy 4 requires an investment of $50,000 each year in a scheduled-ignition program. Because of savings in allowing for more unscheduled prescribed fires, the net increase in program costs is about $43,000. The question for the decision maker is whether increasing the number of average annual burned acres from 14,532 to the lower limit of the historic level is worth $43,000 a year.

RISK

Risk can be defined as the potential for realization of unwanted, negative consequences (Rowe 1977). There is a certain level of risk associated with each fire management strategy. The major risk involved is the probability of a catastrophic wildfire (a fire of any size with one or more of the following characteristics: excessive resource damage, excessive suppression costs, excessive damage to private inholdings, or the loss of life). Catastrophic wildfire can have three origins: (1) a wildfire that escapes initial attack and becomes catastrophic, (2) an unscheduled-ignition prescribed fire that escapes prescription and becomes a catastrophic wildfire, or (3) a scheduled-ignition prescribed fire that escapes prescription and becomes catastrophic. A large fire is not necessarily a catastrophic wildfire and all fires that escape prescription

are not necessarily catastrophic. Although the probabilities involved are small, even a very low probability of a very high cost can be a significant factor (Zivnuska 1968, 1972).

Figure 1 shows the general relationships of a risk cost-benefit model (Rowe 1977). As expenditures are made in fire management (direct losses), risk of catastrophic fire (indirect losses) is reduced and benefits (gains) are increased. Due to uncertainty, the optimal solution lies somewhere in the area where the shading overlaps. A family of curves representing various strategies could be constructed. For strategy 1, the benefits of fire suppression in wilderness areas are minimal, the direct losses are high, and the risk reduction is questionable. On the one hand, some potential catastrophic fires may be suppressed before they become disastrous. On the other hand, fuel continuity and fuel loading may increase over time, thereby increasing the probability or magnitude of a catastrophic fire.

For strategy 2, the benefits are increased over strategy 1, direct losses are not as high, and the risk of catastrophic fire is less. The assumption is made that increased burned acres break up fuel continuities and reduce fuel loads to reduce the probability or magnitude of a catastrophic wildfire. This is not always true; some fires may prepare the way for future catastrophic fires (Wellner 1970).

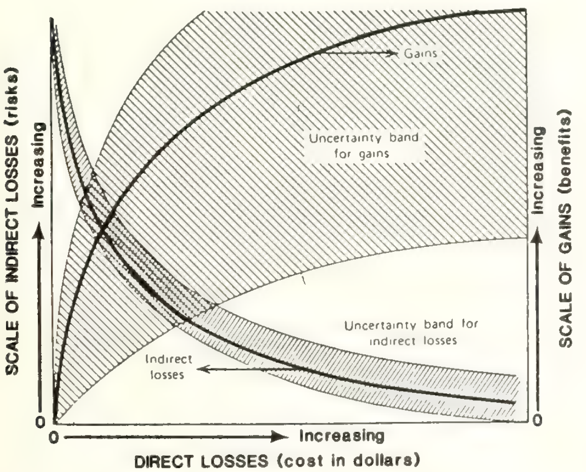

Figure 1.--Risk cost/benefit model (Rowe 1977).

Strategy 3, by incorporating unscheduled ignitions, further increases the benefit, reduces direct losses, and reduces the probability of a catastrophic wildfire. However, strategy 3 introduces the probability of an unscheduled fire escaping prescription and becoming a catastrophic wildfire. Prescriptions ensure the probability of escape is low, yet there is a great deal of uncertainty surrounding what a fire start in July will do in August. After a learning period, the probability of an unscheduled fire escaping prescription and becoming catastrophic should drop to a very low level.

Strategy 4, by incorporating unscheduled and scheduled ignitions, increases the benefit over strategy 3, reduces the probability of a catastrophic wildfire to its lowest level, but increases the direct losses over strategy 3. Again, there is the probability of a scheduled ignition escaping prescription to become a catastrophic wildfire. Prescriptions should ensure that the probability of escape is even lower than that for unscheduled prescribed fires. There is also a learning period here, after which the probability of escape is minimized. Knowledge acquired during the learning period should also have benefits that can be transferred and applied to forest areas outside wilderness, for example in summer burning without constructed handline, advances in knowledge of fire behavior in natural fuels, and controlled crown fires. If the long-term goal is to minimize the risk of catastrophic fire, strategy 4 would appear best. However, there are costs (direct losses) associated with reducing the risk. If net present costs through an infinite time span are determined, the high initial costs associated with strategy 4 may never be offset due to the properties of discounting. Whether or not it would be profitable to invest funds in scheduled ignitions to reduce the probability or magnitude of a catastrophic fire event depends on the initial probability of a catastrophic wildfire, the amount the probability is decreased, and the amount of money spent to decrease the probability.

Lukens and Saveland (1984) showed that the probability of large costly fires and the amount the probability is decreased are very sensitive variables. They also found that in areas where the probability of a large costly fire is small to begin with, prescribed burning to further decrease the probability would not be justified. In areas of high fire occurrence, where there is a high probability of large, expensive fires, prescribed burning could be cost effective. The Frank Church--River of No Return Wilderness is a relatively high fire occurrence area with a high potential for large fires.

The probability of a catastrophic wildfire varies from place to place based on the fire climate and the values at risk. In one area a relatively small investment may dramatically decrease the probability of catastrophic wildfire, while in another area, even a large expenditure would not have much effect on the probability. If the risk is low to begin with, it would not be cost effective to further reduce the risk. On the other hand, a considerable amount of money may be saved by accepting more risk in low-risk areas.

IRREVERSIBLE IMPACTS

Radical departures from the historic long-term average annual burned area can be expected to produce irreversible impacts, just as converting an area from an average of 80 inches of rainfall a year to an average of 10 inches of rainfall a year would be expected to produce long-run

ecological consequences. An analogy can be drawn between Fisher and Krutilla's (1974) example of directing water from the Everglades and continued fire suppression activities. In addition, continued suppression activities can set the stage for a stand replacement fire in a community that is adapted to periodic surface fires, possibly preventing the re-creation of a plant association similar to the one that now exists. A conservative policy with respect to irreversible modification of the environment or decisions that have long-run welfare losses that may be eventually retrieved is indicated (Fisher and Krutilla 1974).

In areas where unscheduled ignitions are severely constrained, scheduled ignitions may be necessary to prevent the long-run ecological consequences of continued suppression. As an example, consider an ecosystem that is dependent on periodic-stand replacement fires, such as certain lodgepole pine (Pinus contorta) communities. If man had not interceded by putting fires out, the natural state would be characterized by a negative exponential age-class distribution at the landscape level with the mean of the distribution equaling the fire cycle (Van Wagner 1978; Van Wagner and Methven 1980). By putting fires out, the age-class distribution has changed. By allowing stand-replacement fires back into the system, the process through time would converge back to a negative exponential distribution. If unscheduled ignitions are constrained, it will take longer to reach a negative exponential distribution and the mean of the distribution (fire cycle) would be greater than the original. If fire is continually suppressed, there is the possibility of these ecosystems being drastically altered or replaced by others.

The use of scheduled ignitions brings up the question of authenticity. Fisher and Krutilla's (1974) analogy between the demand for undisturbed natural areas and the demand for authenticity in the visual arts points out the highly inelastic demand for "originals." Under this analogy, a landscape sculptured by unscheduled ignitions could be considered an original work of art, while a landscape sculptured by scheduled ignitions would be an exact forgery. Unfortunately, all of the "originals" may have been destroyed or damaged by suppression activities. Gruell (1983) presented a dramatic photo record of how suppression activities have affected various communities.

SUMMARY

Wilderness fire management presents several problems for an economic analysis. Because of the problems of value change in wilderness, a cost/benefit analysis was developed. Average annual burned acres and average annual costs were determined using decision analysis. Average annual burned acres as compared to the historic level is a measure of benefit. This method can signal when a scheduled ignition prescribed fire program should be considered. If there are few management constraints, burned area resulting from unscheduled ignitions will closely approximate the historic level and a scheduled-ignition program is unnecessary. If constraints on unscheduled ignitions are binding, thus requiring a lot of suppression activity, a scheduled-ignition program should be considered to maintain natural fire regimes.

Several assumptions and subjective estimates were necessary to complete the decision trees. Guidelines for making assumptions and subjective estimates included: make as few as possible, be consistent, be conservative, check against adjacent wilderness areas if possible, break down major assumptions into more manageable ones, and receive input and feedback from the district fire management officers. The estimates for the rare-event larger size-class fires account for the majority of costs and area burned, and so greatly influence the results. Thus extensive encoding procedures such as those outlined by Selvidge (1975) and Spetzler and Stael Von Holstein (1975) would be appropriate to attempt to come up with more accurate estimates.

Further research is necessary in several areas to reduce the levels of uncertainty. Most fire history studies concentrate on fire scar analysis, yet there is a pressing need for age-class analysis at the landscape level to determine fire cycles for all communities. The subject of risk management as it relates to fire is in its infancy. Probabilities of rare, costly fires need to be determined. How our management actions affect the probability and magnitude of those costly rare events could have large payoffs. As an escaped-fire situation analysis is performed on more fires, a data base needs to be established to document cost savings and the resulting increase in area burned. The size class probability distribution of fires that are allowed to burn needs to be determined. In general, as experience is gained in fire management for the FCRONR Wilderness, a data base can be built to more accurately determine the values that were subjectively estimated.

Results indicate that the greatest cost difference was between strategy 1 and strategy 2. Cost differences between strategies 2, 3, and 4 may not be significant. The burned acres resulting from strategy 4 come closest to the historic level. If scheduled ignitions are used in an attempt to match the historical level, quality of burned acres must also be considered along with quantity. In other words, if the historical level resulted from lightning fires in August, scheduled ignitions in May would not have the same effect. Strategy 4 also results in the lowest costs per burned acre. Each strategy will affect the risk of a catastrophic wildfire. Strategy 4 would reduce the probability or magnitude of a catastrophic wildfire to a minimum level. The main question remains: are the increased benefits and reduction in risk of catastrophic wildfire worth the expenditure of funds for a scheduled-ignition program to augment unscheduled prescribed fires and wildfire suppression?

Each strategy, by affecting the natural fire regime, may also have long-run ecological consequences and irreversible impacts. A conservative policy (one not drastically altering the natural fire regime) to prevent irreversible modification of the environment, or decisions that have long-run welfare losses that may be eventually retrieved is recommended.

The use of scheduled ignitions brings up the question of authenticity. Analogous to the highly inelastic demand for originals in the visual arts, a landscape sculptured by unscheduled ignitions could be considered an original work of art, while a landscape sculptured by scheduled ignitions would be an exact forgery. Unfortunately, all of the "originals" may have already been destroyed or damaged by suppression activities.

REFERENCES

Agee, James K. Cost-effective fire management in national parks. In: Lotan, James M.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., compilers. Proceedings--symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. Gen. Tech. Rep. INT-182. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983; 193-198.

Althaus, Irene A.; Mills, Thomas J. Resource values in analyzing fire management programs for economic efficiency. Gen.Tech. Rep. PSW-57. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1982. 9 p.

Baumgartner, David C.; Simard, Albert J. Wildland fire management economics: a state of the art review and bibliography. Gen. Tech. Rep. NC-72. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1982. 46 p.

Chandler, Craig; Cheney, Phillip; Thomas; Phillip; Traubaud, Louis; Williams, Dave. Fire in forestry. Volume 2: forest fire management and organization. New York: John Wiley & Sons; 1983. 298 p.

Condon, Michael. Economic analysis for wilderness fire management: a case study. In: Lotan, James E.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., compilers. Proceedings--symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. Gen Tech. Rep. INT-182. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 199-205.

Fisher, Anthony C.; Krutilla, John V. Valuing long-run ecological consequences and irreversibilities. J. Environ. Econ. and Manage. 1: 96-108; 1974.

Gonzalez-Caban, Armondo; McKetta, Charles W.; Mills, Thomas J. Costs of fire suppression forces based on cost-aggregation approach. Res. Pap. PSW-171. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1984. 16 p.

Gorte, Julie K.; Gorte, Ross W. Application of economic techniques to fire management - a status review and evaluation. Gen. Tech. Rep. INT-53. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979, 26 p.

Gruell, George E. Fire and vegetative trends in the Northern Rockies: interpretations from 1871-1982 photographs. Gen. Tech. Rep. INT-158. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 117 p.

Hirsch, Stanley N.; Radloff, David L.; Schopfer, Walter C.; Wolfe, Marvin L.; Yancik, Richard F. The activity fuel appraisal process: instructions and examples. Gen. Tech. Rep. RM-83. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1981. 46 p.

Lukens, David M.; Saveland, James M. Environmental assessment of the Gospel-Hump wilderness fire management policy (appendix B). Grangeville, ID: U.S. Department of Agriculture, Forest Service, Nezperce National Forest; 1984. 50 p.

Mills, Thomas J. Criteria for evaluating the economic efficiency of fire management programs in park and wilderness areas. In: Lotan, James E.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., compilers. Proceedings--symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. Gen. Tech. Rep. INT-182. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 182-190.

Radloff, David L. Using decision analysis to evaluate fire hazard effects of timber harvesting. Fire Management Notes, 45(1): 10-16; 1984.

Rowe, William D. An anatomy of risk. New York: John Wiley & Sons; 1977. 488 p.

Saveland, James M.; Hildner, Richard S. Five year review of fire on the Moose Creek Ranger District, Selway-Bitterroot Wilderness. In: Lotan, James E.; Kilgore, Bruce M.; Fischer, William C.; Mutch, Robert W., compilers. Proceedings--symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. Gen. Tech. Rep. INT-182. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 375 p.

Seaver, David A.; Roussopoulos, Peter J.; Freeling, Anthony N. S. The escaped fire situation: a decision analysis approach. Res. Pap. RM-244. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1983. 12 p.

Selvidge, Judith. A three-step procedure for assigning probabilities to rare events. In: Wendt, Dirk; Viek, Charles, eds. Utility, probability and human decision making. Boston: Reidel Publishing Co.; 1975: 199-216.

Simard, A. J. Wildland fire management: the economics of policy alternatives. Tech. Rep. 15. Ottawa, ON: Canadian Forest Service, Forest Fire Research Institute; 1976. 52 p.

Spetzler, Carl S.; Stael Von Holstein, Carl-Axel. Probability encoding in decision analysis. Management Sciences. 22(3): 340-358; 1975.

Thompson, Glenn A. Fire in wilderness areas. Proceeding, Tall Timbers Fire Ecology Conference. 3: 105-110; 1964.

U.S. Department of Agriculture, Forest Service. Environmental statement, fire in the Selway-Bitterroot Wilderness - a proposed policy change, Bitterroot, Clearwater, Lolo, and Nezperce National Forests, Northern Region. USDA-FS-DES (Adm.) R1-76-12. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region; 1976. 229 p.

Van Wagner, C. E.; Methven, I. R. Fire in the management of Canada's National Parks: philosophy and strategy. Occasional Paper No. 1. Ottawa, ON: Parks Canada; 1980. 18 p.

Wellner, Charles. Fire history in the Northern Rocky Mountains. In: Role of fire in the Intermountain West Proceedings; 1970 October 27-29. Missoula, MT. Missoula, MT: Intermountain Fire Council; 1970: 42-64.

Zivnuska. John A. An economic view of the role of fire in watershed management. J. For. 66(8): 596-600; 1968.

Zivunska, John A. Economic tradeoffs in fire management. In: Proceedings, fire in the environment symposium; 1972 May 1-5; Denver, CO. Denver, CO: U.S. Department of Agriculture, Forest Service; 1972: 69-74.

Appendix--Decision tree for strategy 1.

Strategy	Cause	Fire type	Probability	Avg. size (acres)	Expected burned area per fire (acres)	Avg. cost ($)	Expected cost per fire ($)
Strategy 1	88% Lightning	0% Prescribed					
		100% Wildfire	80.8%	0.1	0.07	2,000	1,422
			16 %	2	.28	5,000	704
			2.4%	32	.68	37,000	781
			.4%	362	1.27	289,000	1,017
			.4%	10,047	35.37	3,466,000	12,200
	12% Person-caused wildfire		73.4%	0.1	0.01	2,000	176
			19.1%	2	.05	5,000	115
			4.3%	32	.17	37,000	191
			2 %	362	.87	289,000	694
			1.2%	10,047	14.47	3,466,000	4,991
					53 acres/fire		$22,291/fire

$$\frac{\$22{,}291/\text{fire}}{53\ \text{acres/fire}} = \$421/\text{acre}$$

Appendix--Decision tree for strategy 2.

Strategy	Cause	Fire type	Probability	Avg. size (acres)	Expected burned area per fire (acres)	Avg. cost ($)	Expected cost per fire ($)
Strategy 2	88% Lightning	0% Prescribed					
		100% Wildfire	80.8%	0.1	0.07	2,000	1,422
			16 %	2	.28	5,000	704
			2.4%	32	.63	37,000	781
			.4%	724	2.55	72,000	253
			.4%	15,070	53.05	1,130,000	3,978
	12% Person-caused wildfire		73.4%	0.1	0.01	2,000	176
			19.1%	2	.05	5,000	115
			4.3%	32	.15	37,000	191
			2 %	724	1.74	72,000	173
			1.2%	15,070	21.70	1,130,000	1,627
					80 acres/fire		$9,420/fire

$$\frac{\$9{,}420/\text{fire}}{80\ \text{acres/fire}} = \$118/\text{acre}$$

Appendix--Decision tree for strategy 3.

Strategy	Cause	Fire type	Probability	Avg. size (acres)	Expected burned area per fire (acres)	Avg. cost ($)	Expected cost per fire ($)
Strategy 3	88% Lightning	27% Prescribed	70 %	0.1	0.02	250	42
			15 %	2	.07	250	9
			11 %	40	1.05	250	7
			2 %	750	3.56	1,000	5
			2 %	18,000	85.54	10,000	48
		73% Wildfire	77.3%	0.1	0.05	2,000	993
			18.6%	2	.24	5,000	597
			3.1%	32	.64	37,000	737
			.5%	724	2.33	72,000	231
			.5%	15,070	48.40	1,130,000	3,630
	12% Person-caused wildfire		73.4%	0.1	0.01	2,000	176
			19.1%	2	.05	5,000	115
			4.3%	32	.15	37,000	191
			2 %	724	1.74	72,000	173
			1.2%	15,070	21.70	1,130,000	1,627
					166 acres/fire		$8,581/fire

$$\frac{\$8{,}581/\text{fire}}{166\ \text{acres/fire}} = \$52/\text{acre}$$

Appendix--Decision tree for strategy 4.

Strategy	Cause	Fire type	Probability	Avg. size (acres)	Expected burned area per fire (acres)	Avg. cost ($)	Expected cost per fire ($)
Strategy 4	88% Lightning	37% Prescribed	70 %	0.1	0.02	250	57
			15 %	2	.10	250	12
			11 %	40	1.43	250	9
			2 %	750	4.88	1,000	7
			2 %	18,000	117.22	10,000	65
		63% Wildfire	76.4%	0.1	0.04	2,000	847
			19 %	2	.21	5,000	527
			3.4%	32	.60	37,000	697
			.6%	724	2.41	72,000	239
			.6%	15,070	50.13	1,130,000	3,759
	12% Person-caused wildfire		73.4%	0.1	0.01	2,000	176
			19.1%	2	.05	5,000	115
			4.3%	32	.15	37,000	191
			2 %	724	1.74	72,000	173
			1.2%	15,070	21.70	1,130,000	1,627
					201 acres/fire		$8,501/fire

Unscheduled:	17,596 acres/yr	$744,178/yr
Scheduled:	+ 5,000 acres/yr	+ 50,000/yr
Total:	22,596 acres/yr	$794,178/yr

$$\frac{\$8{,}501/\text{fire}}{201\ \text{acres/fire}} = \$42/\text{acre}$$

$$\frac{\$794{,}178/\text{yr}}{22{,}596\ \text{acres/yr}} = \$35/\text{acre}$$

FIRE IN WILDERNESS: PUBLIC KNOWLEDGE, ACCEPTANCE, AND PERCEPTIONS

Jonathan G. Taylor and Robert W. Mutch

ABSTRACT: The public is more knowledgeable and more willing to accept new wilderness fire practices than they were 10 years ago. Perceptual reactions to scenic quality and recreational acceptability, however, do not necessarily correlate with these changes in knowledge and attitude. Research in this area can improve public understanding of wilderness fire policy and managers' understanding of public response to wilderness fire.

INTRODUCTION

Recent revisions in fire policies of federal land management agencies have shifted emphasis from suppression to fire management (Davis 1979). Instead of strict adherence to the "10 AM Fire Control Policy," revised policies now permit the selection of an appropriate suppression response. Suppression alternatives may range from direct control actions to simply keeping a wildfire under surveillance. Current fire management policies of the National Park Service and USDA Forest Service recognize that prescribed fires are necessary in perpetuating natural ecosystems in national parks and wildernesses. Prescribed fire policies in national parks and wildernesses permit naturally ignited fires to burn under certain prescribed conditions (unplanned ignitions), or through ignition by fire managers (planned ignitions).

Since 1972, the Forest Service has initiated or allowed over 340 prescribed fires in 59,000 acres of wilderness and non-wilderness lands (Kilgore 1984). The National Park Service has allowed or set some 1800 prescribed fires covering over 300,000 acres (Sellers 1982).

Because policy changes that allowed lightning fires to burn as prescribed fires in national parks and wildernesses were a significant departure for both agencies, the National Park Service and Forest Service have been educating the public about these changes. Further, it is important to discover how the public feels about prescribed fire because the public is affected by fire management policies--directly through closures of areas or trails and smoke-decreased visibility, and indirectly through changes in the landscape and effects on wildlife populations. The conclusion of a recent study (McCool and Stankey 1985) is that current visitors to the Selway-Bitterroot Wilderness are somewhat more knowledgeable now about natural fire effects than those questioned in 1971 and are much more willing to accept prescribed fires rather than demanding complete suppression.

Although the public now is more conceptually knowledgeable and supportive of prescribed fire practices, the fact remains that many people still react negatively toward the direct results produced during a fire event. These differences between public conceptual and perceptual response are at the heart of the fire manager's dilemma: "You can hold public meetings, explain your fire policy and program, and get strong support. But when the smoke hits town, you had better expect very different reactions!"

More education may not be the complete answer at this point. It is time to reevaluate both the public's conceptual and perceptual awareness of national park and wilderness prescribed fire programs. We will review recent research results on knowledge, acceptance, and perception of fire and suggest some directions in research and public education that could help place managers in a more proactive position vis-a-vis the public and new fire policies.

WILDERNESS

Wilderness is legally defined, for the United States, in Section 2c of the Wilderness Act of 1964: "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Hendee and others (1977) quote historical sources of the wilderness concept in America (e.g., Aldo Leopold and Bob Marshall) from which the legal definition draws heavily.

Two contrasting wilderness philosophies, the anthropocentric and the biocentric, have been described (Hendee and others 1978). The primary emphasis of the anthropocentric position is that wilderness is managed to facilitate direct human use. The biocentric position places the emphasis

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on perpetuating natural order within wilderness ecosystems because wilderness values for society ultimately depend on the retention of naturalness. Many managers of National Parks and wildernesses have implemented the biocentric approach by approving fire management plans that allow lightning fires to burn. There, the wilderness user is presented with unique opportunities to observe a natural event like fire and its immediate and longer term results.

Ideally, a wilderness fire should be a random occurrence that produces dynamic ecosystem change: killing some trees but leaving others, removing undergrowth in places but also leaving unburned areas, exposing mineral soil, producing open-growth forests or dense pole stands, converting dead organic material to ash, recycling nutrients, restricting some plants and favoring others (Habeck and Mutch 1975). Although some observers may be comfortable with this chain of events, others may not be as willing to accept such rapid, natural changes.

Nash (1973) has described wilderness as an ever-changing, human mental construct. Addressing the Wilderness Fire Symposium in Missoula in 1983, Roderick Nash pointed out that wilderness is a state of mind and that changes in perception constitute changes in wilderness definition. As a most recent example, he discussed the shift, in the U.S., from "safe, coffee-table Sierra Club picture-book wilderness" to a perception of "wilderness in the raw." Wilderness users in America are now addressing more rugged issues such as wilderness-use risk. Dr. Nash suggested that this opens the opportunity for managers to handle wilderness with somewhat less concern over public perceptions of the pristine. Specifically, for fire managers, he suggested that these changed perceptions may be opening up new opportunities for using fire in a more ecologically sound role.

Thus, wilderness exists on several interrelated planes: as legally defined; as sets of biophysical, environmental conditions; and as state of mind. Wilderness management must fit into this balance among what is legal, what is to the best of our knowledge ecologically appropriate, and what is publicly expected or acceptable.

PUBLIC KNOWLEDGE AND ACCEPTANCE OF FIRE

Public acceptance is a central concern to managers responsible for implementing innovative fire programs. Early studies supported the belief that the public viewed all forest fires as bad (Hall 1972), and had demonstrated that vigorous suppression practices received virtually unanimous public support (Hendee and others 1968; Folkman 1973). Evidence will be presented here that public attitudes are changing; however, there is still concern that the public will not be willing to accept less-than-all-out fire suppression (Nelson 1979; Folkman 1979). Nowhere are these concerns more pertinent than in wilderness fire management.

The relationship between fire and forest recreation has been investigated by Stankey (1976), Rauw (1980), and McCool and Stankey (1985). Stankey (1976) investigated 183 wilderness users' knowledge and attitudes concerning fire in wilderness settings in 1971. His sample's performance on the knowledge of fire effects was generally low; the average score was 53 percent correct response to 11 true/false questions. Knowledge was especially low regarding the size of pre-Columbian forest fires, increasing wildfire intensities related to fire suppression, the effects of fire suppression on habitat, and the relation of fire to animal death.

McCool and Stankey's project (1985) "replicates in content and method the Stankey study (1976) of Selway-Bitterroot Wilderness users in order to determine trends." In essence, the later project, conducted in 1984, found wilderness users more knowledgeable about fire effects and substantially more tolerant of allowing fire to burn in wilderness areas than did the 1971 study. The average score for their 275 respondents on the fire knowledge test increased to 64 percent correct responses. Knowledge, however, of pre-Columbian fire size, animal mortality, effects of fire suppression on wildfire intensity, and the effects of suppression on habitat remained relatively low. Correct responses increased significantly for questions regarding fire increasing nutrient availability, suppression's relation to increased wildfire intensity, fire's role in controlling insects and disease, and changes in community structure that could result from fire exclusion.

Selway-Bitterroot wilderness users' willingness to allow fire in wilderness increased dramatically from 1971 to 1984. The least tolerant, complete suppression statement was selected as "most acceptable" by 31 percent of the earlier sample but by only 5 percent of the 1984 sample. In 1971, 56 percent of the respondents chose "fire intolerant" and 40 percent "fire tolerant" statements; those percentages had shifted to 17 percent intolerant and 73 percent tolerant by 1984. Lucas (1985) also reports increasing support, from 1970 to 1982, by visitors to the Bob Marshall Wilderness for allowing natural fires to burn. However, he did not investigate knowledge of fire effects in depth.

Rauw (1980) investigated fire knowledge and attitudes of Olympic National Park users and Olympic Peninsula residents. Nearly half of the 725 respondents reported having been in or near a forest fire at some time, although few had received any personal losses due to fire. Rauw reported that her fire knowledge results suggested that recreation area users and residents were aware of beneficial effects of certain fires, recognized evidence of past fires, knew that certain fires cannot be suppressed, and correctly defined the practice of prescribed burning. Concerning fire attitudes, however, Rauw reported that 65 percent of the sample "felt that all fires should be controlled at any cost," despite the fact that fire was recognized as having some beneficial effects on natural resources, and that the use of prescribed fire for fuel reduction and restoration of native vegetation received support. "This realization does not seem to connect itself to the

actual management alternative that is necessary in order to restore the natural process of fire to the land."

Recently, three other studies have been conducted that directly pertain to public knowledge and acceptance of fire in forests: Taylor and Daniel (1982), Zwolinski and others (1983), and Gardner and others (1985). Taylor and Daniel (1982) surveyed 178 residents of Tucson, Arizona. They examined the effects of different fire-effects information brochures on public knowledge and support for fire management practices. They also tested public perceptions of both light fire and severe fire areas of southwestern ponderosa pine forests.

The fire-effects information brochures administered by Taylor and Daniel produced measurable changes in both public knowledge and attitudes towards fire in ponderosa forests (see Taylor and Daniel 1985). Knowledge areas that showed significant improvements were: the average area generally burned by forest fires; assumed intensity of most forest fires; the numbers of animals killed by forest fires; and the ecological effects of light fire in a ponderosa forest. Interestingly, there was fairly close consensus among the "informed" (those receiving fire effects information), the "uninformed" (those receiving general forest management information without specific reference to fire), and the "expert" (a graduate fire ecology seminar) groups concerning impacts of forest fire on both soil erosion and air quality. In response to the question, "compared to other sources of air pollution such as cars, factories and unpaved roads, how much of a factor do you think forest fire smoke is in air pollution," all three groups indicated "a MINOR factor."

Zwolinski and others (1983) used a telephone survey to poll the general public, sampling 1200 randomly selected residents of the Tucson metropolitan area (see also Cortner and others 1984). Gardner and others (1985) administered a questionnaire by mail and in person to a national sample of 1646 forest users drawn from organized groups of recreationists and resource management professionals (see also Stenberg 1982). These two studies concentrated on public knowledge of fire and fire effects as well as public attitudes toward alternative fire management practices.

Results of the Zwolinski and others, Gardner and others, and Taylor and Daniel studies all point to a high level of public acceptance of current fire management practices, particularly the use of prescribed fire. All three surveys asked respondents the question, "Do you think managers SHOULD or SHOULD NOT periodically burn underbrush and debris in pine forests?" Positive responses ranged from 62 to 92 percent (fig. 1 MANAGERS). The Zwolinski survey asked whether respondents had heard of "prescribed fire, also called controlled burning." Eighty-four percent indicated that they had and of this group, 80 percent approved of the practice (see Cortner and others 1984).

These three surveys, as well as McCool and Stankey's survey, further indicate that the public today does not accept extreme "all-out" fire suppression policies. Zwolinski and others and Taylor and Daniel asked respondents whether they agreed or disagreed with the statement, "No fires should be allowed to burn in pine forests" (fig. 1 NO FIRE). Eighty-two percent of Taylor and Daniel's and 56 percent of Zwolinski and others' respondents disagreed with the statement. Gardner and others asked a related pair of questions of forest users: whether they agreed with the statements, "It is absolutely necessary that all forest fires be put out immediately" (fig. 1 ALLOUT), and "All fires are harmful and should be put out regardless of cost" (fig. 1 COST). Seventy-four percent disagreed with the first statement, and 81 percent disagreed with the latter. McCool and Stankey had only 5 percent of their 1984 sample select the complete suppression statement as best. From these data, the public can be seen as neither blindly accepting nor outright rejecting fire in pine forests.[1]

Indeed, the public demonstrates some fairly sophisticated discrimination in acceptance or rejection of allowing fires to burn in forests. The Zwolinski and others, Gardner and others, and Taylor and Daniel surveys asked respondents whether fires should be allowed to burn: if they were started by LIGHTNING, if they were started by human carelessness [HUMANS]; or if they were burning UNDERBRUSH and DEBRIS but not the tall trees. As figure 2 shows, although the public favors putting out fires caused by both lightning and human carelessness, the latter is more strictly rejected. Over half of the public in all three surveys are willing to tolerate the presence of light-intensity fires.

Relationships of Fire Knowledge to Acceptance of Fire Practices

Stankey (1976) reported "a strong correlation between the fire knowledge test score and the attitude statements selected as acceptable. Knowledge of the individual's test score explained 57 percent of the variance in the selection of the 'most acceptable' statement" regarding fire suppression policy. Essentially, the more wilderness users knew of the effects of forest fire, the more willing were they to tolerate fire in a wilderness.

Figure 2 shows that participants in the Taylor and Daniel survey who received information detailing the effects of both light and severe fires showed a significantly greater tolerance for light intensity, UNDERBRUSH and DEBRIS, fires than those who did not receive such information.

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[1]The use of the term, "the public," here refers to the populations sampled. Since these research results were generated by some 3500 respondents, approximately 1375 from Tucson, Arizona; 450 from Montana; and 1650 from a nationwide sample, they begin to approximate a general sample of the U.S. public.

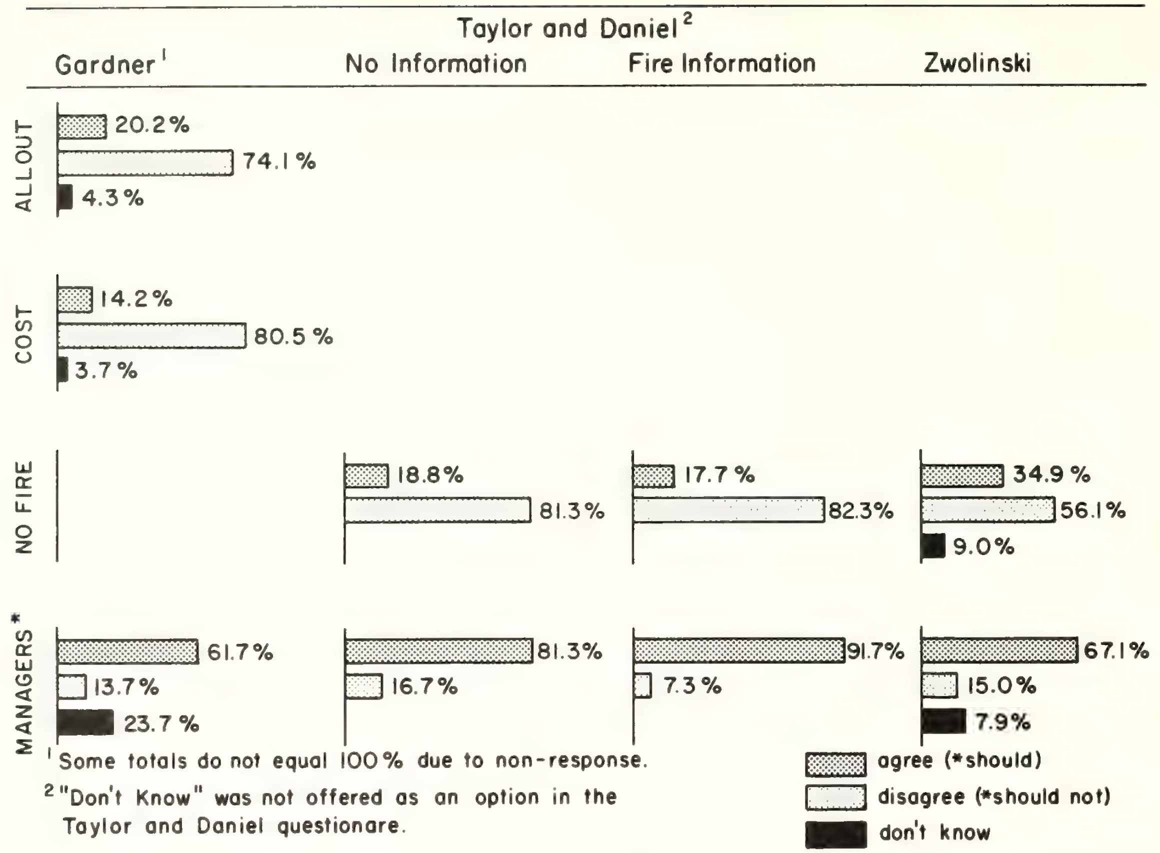

Figure 1.--Public support for strict suppression versus prescribed burning.

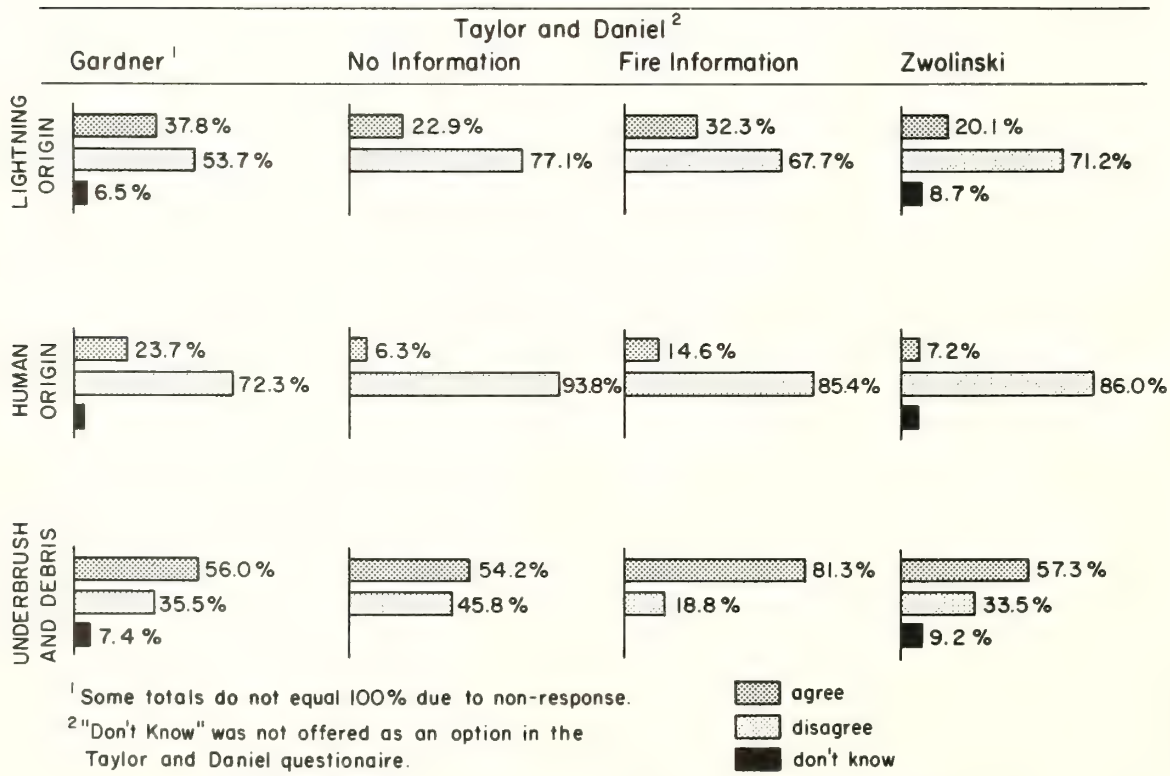

Figure 2.--Public tolerance of fire by origin and intensity.

In a survey of public attitudes toward fire management alternatives for the Frank Church-River of No Return Wilderness in Idaho, Patten and Oliver (1985) provided wilderness users with a fact sheet presenting fire ecology information and basic fire issues such as safeguarding public life and property, fire effects on wildlife and fish habitat, and smoke effects from large fires. When selecting preferred fire-management alternatives, none of the respondents chose the "suppression only" alternative, 24 percent of the respondents selected the alternative that allowed prescribed fires from lightning ignitions, and two variations that permitted prescribed fires from lightning and manager ignitions were supported by 71 percent of the respondents. Here again, when provided with information regarding fire effects and safeguards the public tends to be supportive of prescribed fire programs.

To gain further insight into audience targeting and program content for forest fire education, Carpenter and others (in press) compared portions of the Taylor and Daniel, Zwolinski, and Gardner studies. First, increasing public acceptance is demonstrated as fire conditions are more completely defined and as greater management is implied. Public tolerance increases from 20-22 percent for fires "already burning," to 54-81 percent for "underbrush and debris fires," to 62-92 percent for fires conducted by forest managers. Carpenter and others conducted log-linear analysis of the Zwolinski and others data, using four alternative fire management practices as dependent variables and "fire beliefs" plus sociodemographic characteristics as independent variables. Dependent variables included approval of fires already burning, underbrush and debris fires, fires set by managers, and "prescribed fires." Independent variables included beliefs about fire origin, fire intensity, fire area, animal mortality, and whether fires have beneficial effects; as well as the sociodemographic characteristics of age, family income, education, and sex.

The implications for targeting audiences derived from these analyses are fairly complex (table 1). In terms of sociodemographic characteristics, there is no easily differentiable segment of the adult population to effectively target with general fire management information. For example, early chi square analysis (Zwolinski and others 1983) indicated that females tended to be less tolerant in their attitudes toward fire, and thus might be an appropriate sub-population to target with fire information. Multivariate analysis, however, shows that sex interacts with beliefs and age, and is meaningful only in explaining approval of fires already burning or approval of prescribed fires (table 1). Demographics do not appear to be good predictors of overall attitudes toward fire in pine forests. Targeted audiences, for <u>general</u> fire information programs, should include <u>a broad</u> cross-section of the adult population.

Table 1.--Summary of relationships: fire beliefs and sociodemographic characteristics with approval for fire management practices

Management Alternatives	Already Burning	Underbrush & Debris	Managers Burn	Prescribed Fire
(% approval)	(22)	(64)	(82)	(92)[1]
INDEPENDENT VARIABLES				
<u>BELIEFS</u>				
Beneficial effects	Benefit	Benefit[2]	Benefit_s	Benefit x Age
Fire Origin	Origin x Sex	Origin	Origin_s	Origin
Fire Area	Area x Sex	Area		
Animal Mortality	Mortality x Sex	Mortality		
<u>SOCIODEMOGRAPHICS</u>				
Sex	Sex x Origin Sex x Area Sex x Mortality			Sex x Age
Age		Age x Ed	Age x Ed	Age x Benefit Age x Sex
Education		Ed x Age	Ed x Age	
Income			Income	

[1]Percent of those having heard of prescribed fire or controlled burning.
[2]Subscript "s" indicates saturated model.
Source: Carpenter and others, in press.

Four primary areas of belief about fire effects serve to differentiate between respondents in the Zwolinski study who approve and disapprove of fires in pine forests loosely described as "already burning" or "burning underbrush and debris." Approval is tied to beliefs that fires can have beneficial effects, are generally started by lightning, burn relatively small acreages, and kill few animals. As the fire condition is more closely defined, including the deliberate actions of forest managers in starting and controlling the fires, beliefs about fire area and animal mortality drop out as explanatory variables. Approval, however, remains contingent upon belief that fires can have beneficial effects and that most fires in southwestern pine forests are caused by lightning (table 1).

Important implications can be derived from these results, especially if we pay attention to cross-correlations between what people believe about fire effects and those beliefs which correlate with tolerance of fire in wilderness or other forest systems. Carpenter and his coworkers found that the recognition that fire can have beneficial effects on a forest correlated with approval of all four fire types shown in table 1. Recognition of the beneficial effects of fire has a pervasive influence on approval of current fire management alternatives. In the case of activities labeled as "prescribed" or "controlled," approval is 9 to 33 times more likely among those recognizing beneficial effects; they are 4.2 times more likely to approve allowing the "already burning" fire than are people who do not recognize beneficial effects of fire. Beneficial effects questions in McCool and Stankey's survey ranged from 59 percent to 84 percent correct responses, and all increased over the 1971 scores found by Stankey. Zwolinski and others found 68 percent of their respondents recognized some beneficial fire effects.

Knowledge that lightning starts most fires in western ponderosa pine forests relates to approval of these fire types as well. People indicating lightning origin range from 1.7 to 2.7 times more approving of fires already burning and prescribed fire, respectively, than respondents who selected human carelessness as the principal origin of forest fire. Knowledge of lightning origin, however, shows a quite different pattern than beneficial effects. McCool and Stankey had 63 percent correctly respond to their question about fire origin, no change from the 1971 data. Taylor and Daniel had 41 percent correctly identify lightning as the principal fire origin in southwestern ponderosa pine forests, fire information having made no difference for these responses. Of the Zwolinski sample, only 23 percent correctly identified lightning as the principal fire origin, 68 percent felt most fires were started through human carelessness.

Pertinent to this discussion are the data that over two-thirds of all the respondents in the surveys by Zwolinski, Taylor and Daniel, and Gardner disapproved of allowing fires started by lightning to continue to burn. The lightning origin question used in these three surveys, however, did not specify fires burning under prescribed conditions, so one must be very cautious about carrying implications too far. Nevertheless, there are important implications to this intertie among approval of fire practices, recognition of the significance of lightning origin of forest fires in the interior mountain west, and acceptance of allowing lightning-caused fires to burn. At least, it should be apparent that a public education campaign is in order to inform the public of prescribed lightning fires; that these prescribed fires, started by lightning, are carefully monitored and managed under conditions as closely defined as those prescribed fires from planned ignitions.

Recognition that most fires are small in area (1.9-to-1) and that relatively few animals are killed by most forest fires (1.5 to 2.5-to-1) are significant in explaining approval for allowing fires "already burning" and "burning underbrush and debris" to continue as long as they're watched. However, these items of fire-effects knowledge score rather low. Fire size had the lowest correct scoring in Stankey's and McCool and Stankey's surveys: 23 percent and 26 percent, respectively. Of Zwolinski's respondents, 44 percent felt thousands of acres were usually burned, 30 percent felt hundreds of acres, and 15 percent felt 1-100 acres. Taylor and Daniel's fire information brochures shifted this belief toward smaller size estimates.

Beliefs about animal mortality show a similar pattern to fire size beliefs. About half of McCool and Stankey's respondents recognized that fire doesn't normally kill off the majority of wildlife, but that is virtually unchanged from Stankey's 1971 responses. Fifty-nine percent of Zwolinski and others' sample thought "lots of animals" were killed by intense forest fires; 29 percent thought a "moderate" number; only 8 percent felt "few animals" were killed. Taylor and Daniel found a shift toward believing fewer animals were killed as a result of reading the fire-effects information brochures. In essence, for fire size and animal mortality, the public's beliefs can be shifted but incorrect assumptions are persisting in the absence of information to the contrary.

PUBLIC PERCEPTIONS OF FIRE IMPACTS

Zube and others (1982) surveyed landscape perception articles in 17 journals published in the fields of landscape architecture, forestry, recreation, geography, environmental studies, and psychology. For the 16-year period 1965 through 1980, 160 landscape perception articles were published, one-fourth pertaining to forestry: 32 on forest scenic quality and 7 on forest recreation. As of 1980, however, only one empirical study had been found that specifically related scenic quality to the effects of fire in forests, and these results were not published until 1982. Anderson and others (1982) concluded that a rapid scenic recovery may occur following light, prescribed fire in ponderosa pine forests.

Taylor and Daniel's perception testing covered public estimations of scenic quality and recreational acceptability for mature ponderosa forest areas that had experienced light fire or severe fire from 1 to 5 years prior to the study. Respondents rated scenic quality higher for slides showing light fire areas than for the "control" forest areas which had been free from fire for 100 years. Light fire enhanced public perception of scenic quality for each of the five post-fire years depicted. Severe fire resulted in serious scenic deterioration (Taylor and Daniel 1984).

Preliminary results obtained on acceptability of burn areas for outdoor recreation showed marked differentiation according to the type of recreation respondents selected as their preferred activity (Taylor and others, in press). Campers showed the greatest sensitivity to fire effects, with strong negative reaction to severe fire effects, as well as slight negative reactions to light fire effects. Picnickers ranked second in sensitivity to severe fire effects. Hikers/backpackers were next most sensitive; their judgments of recreational acceptability were comparable to the overall sample's scenic quality acceptance for severe fire. Respondents choosing Nature Study were least sensitive to fire effects. Light-fire and no-fire areas showed no real differences in acceptability for any of the recreational activities selected, other than for camping.

One important result of the Taylor and Daniel study was that although fire effects information affected both fire knowledge and attitude, perceptual judgments were not affected by information treatments, at least in this short-time testing situation. This indicates that although forest users can increase their understanding of fire as well as their approval of managers' use of it, that doesn't necessarily change their aesthetic evaluation of the area nor their willingness to recreate there.

WILDERNESS MANAGEMENT AND THE NEED FOR FURTHER RESEARCH

Researchers, wilderness managers, and the public represent an important three-way interaction. Managers have a vested interest in applying research results in their wilderness management strategies. Equally important, the research community must be sensitive to the problems and needs of the resource manager. Wilderness researchers and managers must find out what the public knows and is willing to accept, in the context of the present discussion about wilderness fire. These results will modify, to a certain extent, the wilderness management program, but will also identify key areas for public information and education.

Although survey results such as those reported here should be encouraging to wilderness fire managers, these professionals recognize there are still serious problems in public acceptance of wilderness fire policy. An interagency task force met in Missoula, Montana, in 1984 to identify public issues relating to fire management practices. This task force was made up of fire management personnel from several different federal and state resource management agencies. The priority issues they identified were:

1. The media may misinterpret prescribed fire practices and terminology.

2. The general public and some agency employees lack sufficient knowledge of fire effects and the role of fire as an ecosystem process.

3. Some Smokey Bear fire prevention materials may be counterproductive to the goals of prescribed fire programs.

4. Numerous public and political comments are concerned only with the detrimental aspects of fire.

5. Some publics have lost confidence because agencies haven't always demonstrated the necessary knowledge and skills to conduct prescribed fires in a professional manner.

6. The public is being confronted by disjointed dissemination of information because prescribed fire awareness has not been approached on a planned interagency basis.

7. The public has not received adequate quantitative feedback on the results of prescribed fires.

8. Agencies have not prepared the public to cope with the actual prescribed fire, its immediate effects, and post-fire plant succession (including risk of escape, smoke dispersal, and vegetation and wildlife response).

9. Agencies have not taken full advantage of environmental education opportunities through the school system, county fairs, and youth groups.

10. Agencies have recognized the value of a continuing public information program. Too often information efforts have been focused on the individual prescribed fire, or are reactive to criticism rather than carrying out an ongoing, positive education effort.

By far the majority of these priority issues relate directly to public education. Thus an obvious need is being expressed for coordinated, quality programs of public education concerning fire management practices and their results. However, it is also important to keep clearly in mind that public education is a two-way process. Not only must we inform the public about the actual short-term and long-term effects of prescribed fire, and of current fire management practices; we must also inform ourselves of what the public knows about these events, their willingness to accept new fire practices, and their perceptions of the various impacts of these fires. Research cited earlier, for example, indicates it is important that wilderness fire managers clarify the roles played by both planned- and unplanned-

ignition prescribed fires. It is the process of informing ourselves that points out that this is a very sensitive area requiring public education.

The research results cited, as well as the priority areas listed by fire managers, suggest several avenues of important future research. Research into fire knowledge and acceptance should be expanded in time, i.e., longitudinal studies; and in space, into other regions with different forest types and with different public experience. These survey instruments can be easily modified, and should be, to respond to specific management problems at local or district levels. These lines of research should help clarify about which aspects of fire management and fire impacts the public is ignorant or misinformed. Aspects of fire knowledge which are key to public acceptance of fire management practices, under new fire policies, can be refined.

In the general area of public information and education, this research agenda can be expanded to better represent the national public, or regionally refined to allow development of I and E programs tailored to more local conditions, both ecological and in public understanding or acceptance. Such I and E programs should be tested and critically evaluated before wide dissemination.

Perception research has received very little attention relative to the contributions it can make to understanding public reactions to wilderness fire management. So far, research into public perceptions of fire impacts has been limited to one forest type and one geographic subsample: ponderosa pine and Arizona. Preliminary results from Taylor and Daniel's work suggest that perceptual scenic and recreational reactions may not correspond with conceptual knowledge and acceptance of fire effects. This line of research needs to be expanded to other regions, and applied to specific fire management problems. An example of the latter would be an impact perception study of changes in response at the time when actual effects of a wilderness prescribed fire were being experienced.

As a result of the priority areas and research cited earlier, the authors are proposing two specific research steps relating to public education to help place the wilderness fire manager in a more favorable role in terms of public attitudes and perceptions. The first is to prepare and test education instruments to help the public anticipate actual short-term and long-term effects of real wilderness fires. Second is to develop a "quick response" test to evaluate the public's immediate perceptions of smoke and other short-term fire effects during actual fire events.

Education of the Public

Taylor and Daniel developed and tested a set of information brochures comparing the effects of light (prescribed) and severe fires on vegetation, wildlife, watersheds, air quality, and general ecosystem composition in southwestern ponderosa pine forests. These were rather sophisticated brochures, using line drawings and production function graphs to depict fire effects. The results of testing these fire-effects information brochures showed that the information was effective in increasing knowledge of some areas of fire effects but was not universally successful in increasing knowledge in all areas tested. The brochures require refinement, a result to be expected following a first-run test of the instruments. The brochures were quite effective in increasing respondents' willingness to accept fire management practices such as prescribed burning and allowing fires to clear out underbrush and debris.

Of primary importance is the fact that these educational materials treated the respondents as mature adults. It was assumed that the people reading these brochures were intelligent and able to absorb some rather complex information. The results of the various surveys discussed earlier show that the public is becoming more sophisticated in their knowledge and attitudes toward fire in forest ecosystems. Their knowledge is a mixture of good information in some areas and misinformation in others; attitudes are changing, becoming much more supportive of new fire policies, but not offering carte blanche. Strict suppression is rejected but so is allowing fires to burn in general. As greater management of fire is indicated, greater acceptance is afforded. If we want the public to respond to wilderness fire management practices in an intelligent and mature manner we must treat them as intelligent adults in our information programs.

The first of our two proposed research steps is to refine and retest these public information brochures. The impacts of fire, and the kinds of prescribed burning that are appropriate differ from area to area. Therefore, it follows that educational instruments for the public must also vary from one fire regime to another. The public is becoming more sophisticated in their understanding of wilderness fire programs, educational programs must rise to this new level of sophistication.

Education by the Public

Whereas Taylor and Daniel found their information brochures to have important effects on both respondents' knowledge and attitudes towards fire in forests, the brochures did not affect respondents' perceptions of scenic quality or acceptability of the burn areas for outdoor recreation. Fire effects information affected cognitive responses but not necessarily affective perceptual responses, at least not in the short time context of that testing situation. Finding differences between what people say they are willing to tolerate and what they actually accept when the event occurs is not new to the fire manager; acceptance in principal and gut-level reaction are not one and the same.

Most survey respondents assess fire management alternatives and prescribed fire effects from within the comfort of their own homes. No wonder they change some of their attitudes when they have

the opportunity to face an actual fire in terms of Nash's "wilderness in the raw!"

We are proposing to conduct "quick response" surveys of people's perceptions within and near a wilderness while a large fire or series of fires is burning. This quick response survey would combine perception testing with questionnaire surveying to detail fire knowledge and attitude. Under this program, interviewers would be trained and ready to travel quickly to areas where planned-ignition wilderness prescribed fires are anticipated or to areas where and when an unplanned-ignition prescribed fire occurs in a wilderness area. Results of these "quick response" applications would be compared with results of applying the same survey when smoke impacts were not occurring. This comparison should yield some valuable insights into how people change when directly experiencing wilderness fire impacts, and in what ways abstract logical responses differ from perceptual preferences.

An ideal location for conducting such a survey would be the Selway-Bitterroot Wilderness in northern Idaho and the adjacent Bitterroot Valley located east of the Selway-Bitterroot in western Montana. This 1.3 million acre wilderness has had an active wilderness prescribed fire program since 1972 when the first Forest Service plan was approved for the 100 square mile White Cap Creek area. Since that time 186 prescribed fires have burned more than 40,000 acres on the Bitterroot, Clearwater, and Nezperce National Forests within the wilderness. The large size of the wilderness, abundance of lightning, and flammable fuel types practically assure that prescribed fires will be present during most years. Past prescribed fires have ranged in size from spots to the 16,000 acre Independence Fire in 1979. Previous visitors to the area have been surveyed by Stankey (1976) and McCool and Stankey (1985), thus providing some baseline information about attitudes towards wilderness fires.

CONCLUSIONS AND INTERACTIONS

This discussion began noting the necessity of viewing wilderness, and consequently wilderness management, from the dual perspectives of ecosystem and human point-of-view. What is required to maintain wilderness ecosystems must be balanced with what is required to maintain wilderness as defined by the public. Research has shown that a great deal has changed over the past ten years. Public definition of wilderness is becoming more rugged, implying some greater latitude for wilderness fire managers. Research into public knowledge and acceptance of fire in wilderness and other forest areas suggests that the public is gaining sophistication in certain areas of fire knowledge such as ecosystem effects, insect and disease control, nutrient cycling, and reduction of fuel loading; but lagging in other areas such as the acreage covered by most fires and animal mortality.

Tolerance of prescribed burning is certainly increasing, but the connection between fire prescriptions and unplanned ignitions appears to be weak for some members of the general public. Several studies have pointed out that people with greater knowledge of fire effects tend to be more tolerant of new fire management policies, but we can go beyond that. Evidence from one area shows that knowledge of beneficial effects correlates closely with acceptance of fire management practices, so too does recognition of lightning, in the interior mountain west, as a principal cause of forest fire. These research results are beginning to identify which information areas are most important in designing public education programs.

In addition to educating the public, it is quite important for the wilderness research and management communities to educate themselves about the public. Evidence has been cited that although knowledge and attitude about fire are related, they do not necessarily imply a linkage with perceptual preferences. Increasing fire knowledge increases stated tolerance of fire practices, but does not necessarily affect public perceptions of scenic quality or acceptability of burn areas for recreation. Further, fire managers report that communities which express support in theory for resource management agencies' fire policies seem to show very different reactions to impacts of actual fires.

The authors suggest several areas of research to directly serve wilderness fire managers' needs. Two specific proposals offered are: First to refine and test public information programs that take advantage of what has been discovered about levels of public sophistication, gaps in public knowledge, and key variables in public support of current fire management practices. Second is investigation of affective perceptual responses to actual fire events and their impacts. These two programs could move a long way towards putting the wilderness fire manager into a more proactive, leadership position in wilderness fire policy. Resource management agencies have moved from reactive, all-out suppression response to wildfire toward much more sophisticated fire management and prescriptions. It is time to develop interactions with the public that can achieve comparable levels of sophistication and prescription.

REFERENCES

Anderson, L. M.; Levi, D. J.; Daniel, T. C.; Dieterich, J. H. The esthetic effects of prescribed burning: A case study. Res. Note RM-413. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1982. 5 p.

Arthur, L. M.; Daniel, T. C.; Boster, R. S. Scenic assessment: An overview. Landscape Planning 4: 109-129; 1977.

Carpenter, E. H.; Taylor, J. G.; Cortner, J. H.; Gardner, P. D.; Zwolinski, M. J.; Daniel, T. C. Targeting audiences and content for

forest fire information programs; to appear in Journal of Environmental Education; in press.

Cortner, H. J.; Gardner, P. D.; Taylor, J. G.; Carpenter, E. H.; Zwolinski; M. J., Daniel, T. C.; Stenberg, K. J. Uses of public opinion surveys in resource planning. To appear in The Environmental Professional; in press.

Cortner, J. J.; Zwolinski, M. J.; Carpenter, E. H.; Taylor, J. G. Public support for fire management policies. J. For. 82(6): 359-361; 1984.

Davis, J. B. A new fire management policy on Forest Service lands. Fire Technol. 15: 43-50; 1979.

Fischer, W. C. Wilderness fire management planning guide. Gen. Tech. Report INT-171. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984.

Folkman, W. S. Urban users of wildland areas as forest fire risks. Res. Paper PSW-137. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1979. 22 p.

Folkman, W. S. Butte County, California residents: their knowledge and attitudes about forest fires reassessed. Res. Note PSW-297. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1973. 5 p.

Gardner, P. D.; Cortner, H. J.; Widaman, K. F.; Stenberg, K. J. Forest user attitudes towards alternative fire management policies. Environmental Management; 1984.

Habeck, J. R.; Mutch, R. W. Forest and forestry. New York: McGraw-Hill Yearbook Science and Technology, McGraw-Hill Book Co., Inc.; 1975.

Hall, A. D. Public attitudes toward fire. In: Proc. Symposium on Fire in the Environment. Rep. 276. Denver, CO: U.S. Department of Agriculture, Forest Service; 1972: 57-63.

Hendee, J. C.; Catton, W. R.; Marlow, L. D.; Brockman, C. F. Wilderness users in the Pacific Northwest: Their characteristics, values, and management preferences. Res. Pap. PNW-61. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1968. 92 p.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Misc. Pub. No. 1365. Washington, DC: U.S. Govt. Printing Office, U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Kilgore, B. M. Restoring fire's natural role in America's wilderness. Western Wildlands 10(3): 2-8; 1984.

Lucas, R. C. Visitor characteristics, attitudes, and use patterns in the Bob Marshall Wilderness complex. Res. Pap. INT-345. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985. 32 p.

McCool, S. F.; Stankey, G. H. Visitor attitudes toward wilderness fire management policy--1971-84. Res. Pap. INT. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; in press.

Nash, R. Wilderness and the American mind. New Haven, CT: Yale University Press; 1973. 300 p.

Nelson, T. C. Fire management policy in the national forests: a new era. J. For. 77: 723-725; 1979.

Patten, T.; Oliver, M. Frank Church: River of No Return wilderness fire management plan. (Final draft) U.S. Department of Agriculture, Forest Service; 1985. 194 p.

Rauw, D. M. Interpreting the natural role of fire: Implications for fire management policy. In: Proc. 6th Conf. on Fire and Forest Meteorology, Soc. Am. For.; Washington, DC; 1980: 228-233.

Sellers, R. E. Historical summary of prescribed fire in the National Park Service. Boise, ID: National Park Service, Branch of Fire Management, Interagency Fire Center; 1982.

Stankey, G. H. Wilderness fire policy: An investigation of visitor knowledge and beliefs. Res. Pap. INT-180. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1976. 17 p.

Stenberg, K. J. The knowledge and attitudes of forest users towards the effects of forest fires and fire management policies. Riverside, CA: M.A. Thesis; 1982. 100 p.

Taylor, J. G.; Cortner, H. J.; Gardner, P. D.; Daniel, T. C.; Zwolinski, M. J.; Carpenter, E. H. Recreation and fire management: Public concerns, attitudes, and perceptions. To appear in Leisure Sciences; in press.

Taylor, J. C.; Daniel, T. C. Perceived scenic and recreational quality of forest burn areas. In: Lotan, J. E.; Kilgore, B. M.; Fischer, W. C.; Mutch, R. W., tech. coords. Proceedings--symposium and workshop on wilderness fire; 1983 November 15-18; Missoula, MT. Gen. Tech. Rep. INT-182. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985: 398-406.

Taylor, J. G.; Daniel, T. C. Prescribed fire: Public education and perception. J. For. 82(6): 361-365; 1984.

Taylor, J. G.; Daniel, T. C. Scenic and recreational perceptions of forest burn areas and the effects of fire information on public knowledge and attitude. Tucson, AZ: University of Arizona; SRNR Report; 1982. 158 p.

Zube, E. H.; Sell, J. L.; Taylor, J. G. Landscape perception: Research, application, and theory. Landscape Planning 9: 1-33; 1982.

Zwolinski, M. J.; Cortner, H. J.; Carpenter, E. H.; Taylor, J. G. Public support for fire management policies in recreational land management. Tucson, AZ: University of Arizona; SRNR Report; 1983. 160 p.

Section 2. Wilderness Air Quality Research

SUMMATION AND COMMENTARY ON RESEARCH NEEDS FOR PROTECTING WILDERNESS AIR QUALITY

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Session Coordinator

The Wilderness Act and the Clean Air Act provide specific mandates to wilderness managers to protect certain values. The Clean Air Act is more narrowly focused, identifying specific attributes to be protected, and providing regulatory tools to accomplish the mandate. Unfortunately, the information necessary to carry out the statutory mandate is sparse or non-existent. The information and tools needed include research from biological, geochemical, meteorological, and sociological disciplines.

This session attempts to present not just the completed or ongoing research, but the basis for needed research and insight into management needs not yet being met by the research community. In this vein, the opening paper sets the stage by addressing the legislation and regulations which direct managers to prevent degradation of wilderness values. We receive a glimpse of the legislative history and the Congressional intent regarding Air Quality Related Values. The author exposes us to some thorny problems which go with wilderness air quality protection, and points out that Congress "painted with a broad brush," dealing in concepts, leaving "much to be filled in." The author speaks of uncertainty and of legal and permitting strategies which can protect wilderness values if resource data is available to support them.

The next paper presents the manager's point of view, identifying the nature of the data and tools needed to redeem the responsibilities spoken of in the first paper. It is ironic that the greatest statutory protection is provided for areas for which the least biological information is available: wilderness. The author speaks of "conservative standards" necessitated by lack of research, and introduces the notion that the wilderness manager is directed to go beyond the prevention of damage; the goal is to prevent man-caused change. The following presentation continues the concept of standards and limits, and discusses the basis for limits and potential strategies for making them effective in protecting sensitive wilderness resources. As in prior presentations, the point is made that resource data is key to the success of these strategies.

Two succeeding papers present research which provides wilderness managers with tools to be applied in making wilderness air quality protection decisions. The first deals with air pollution dispersion modeling, and the second with the ranking of areas for sensitivity to certain air pollutants. The final presentation addresses the question of a wilderness measurement program and discusses some basic questions which need answers before a measurement program is launched.

The session can best be summarized by briefly stating some questions which need to be answered through research by the disciplines mentioned earlier.

Biological: What are the likely effects of pollutants on organisms which are currently stressed and may be living at the edge of their biological range? What effects can be expected from interactions or synergistic effects of air pollution and other stress factors? What is the role of pollution-sensitive organisms, such as lichens, mosses, macroinvertebrates, in food chains and in general ecosystem development and function? How much stress can they take? How long will it take them to recover if severely stressed?

Geochemical: What are the expected weathering rates of different geologic types? How long does it take to exhaust buffering capacity? What is the total role of calcium in buffering? How long will it take to recover an acidified aquatic system? Is there a predictable relationship between elevational gradient and sensitivity to acidification?

Meteorological: How reliable are predictions of pollutant concentrations in complex terrain (where most wildernesses are located)? Is the influence of elevation a meteorological phenomenon?

Sociological: In setting limits of acceptable change, what is important to people? Is it only what they can see, or are things they don't notice also important?

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Questions which apply to all disciplines: What do we measure? How do we measure? How do we use the data?

A large part of the problem of managers who are charged with protecting air quality-related values is their discomfort with their new role, caused by inexperience and, more importantly, by uncertainty about how they can support their decisions. These decisions involve huge sums of money, and significant local and regional economic factors. As an example, the Riley Ridge gas sweetening projects provide 4500 jobs in western Wyoming during a 2- to 3-year construction phase, and over 2000 jobs over several decades of operation. Wilderness managers' decisions about air quality-related values and limits of acceptable change to wilderness will ultimately govern the size of industrial operations such as Riley Ridge and Colorado oil shale. If these managers are to be successful in protecting wilderness values, they must be provided with the research tools and biological information discussed in these papers.

INFLUENCE OF DISTANT AS OPPOSED TO LOCAL POLLUTION TRANSPORT ON WILDERNESS AIR QUALITY

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and Richard T. McNider

ABSTRACT: Using a straightforward synoptic climatological analysis scheme, it is shown that the potential for an area to experience air quality degradation due to local sources is highest under polar and subtropical highs. With respect to polar highs, the problem is most severe when the sun angle is low and snow covers the ground, and the polar high persists for a long period of time.

A simple algorithm is introduced which is designed to estimate worst case impact in a trapping valley. The potential for the accumulation of air pollution in such valleys due to the persistence of a polar high in a region is ignored in current regulatory air quality assessments. Trapping valleys and synoptic flow stagnation often occur in wilderness areas.

Refined air quality assessments are shown to be possible using a mesoscale meteorological model and a pollution dispersion model. These tools permit quantitative assessments of pollution build-up from local sources as a result of the recirculation of the local air. This tool, along with the synoptic climatological classification scheme, also permits an evaluation of the fractional contribution of long range versus local sources in the air quality degradation in a region. Areas near the center of a polar or subtropical surface high pressure system, for instance, appear to be dominated by local sources, if they exist, whereas in the vicinity of extratropical cyclones, long range transport is usually much more important.

Paper presented at the National Wilderness Research Conference, Fort Collins, CO, July 23-26, 1985.

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INTRODUCTION

One of the reasons for formally establishing Wilderness areas is to preserve regions in which the impact of man is minimal. This is the rationale for the goal to ban motorized vehicles, permanent structures and roads in such areas. Unfortunately, however, man can impact these purportedly pristine areas in a direct fashion through the movement of air pollution. In National Park areas, Everhart (1983) concludes that air pollution is the single most important threat to the quality of the National Park system.

The purpose of this paper is two-fold:

- first, to identify those synoptic meteorological conditions in which the impact of air pollution would be most pronounced. As will be shown in the next section of this paper, the frequency with which specific synoptic conditions occur will be shown to vary across the United States and from season to season. This suggests that the potential for air quality degradation in wilderness areas will depend on where they are located, in addition to the magnitude of emissions from nearby pollution sources.
- secondly, since existing observations in and adjacent to wilderness areas are invariably insufficient to adequately characterize the wind flow and turbulence within these areas, mesoscale meteorological models, as discussed later in this paper, represent an alternative tool for needed meteorological assessments. The atmospheric conditions generated by the models are primarily forced by the interaction of meteorological circulations driven by differential gradients in the terrain surface with synoptic features in the overlying atmosphere.

The need to adequately characterize the meteorology in and near wilderness areas is paramount if accurate estimates of air pollution effects are to be achieved. As discussed later in this paper, current regulatory tools used to assess worst case air quality impact in complex terrain, often very inaccurate and misleading, are 10 to 20 years behind current technological capabilities.

Classification of the General Circulation

The general circulation of the earth can be schematically conceptualized into major regions, as illustrated in figure 1. The regions dominated by persistent subsidence are associated with deserts, while regions with average ascending motion generally have significant precipitation. These regions of average upward and downward motion move poleward in the summer, equatorward in the winter. While the influence of continents, mountains and other geographic features alter the specific pattern, the general circulation framework illustrated in figure 1 is a useful backdrop with which to discuss air quality characteristics.

From figure 1, the general ability of air pollution to disperse can be interpreted. Not surprisingly, sinking air creates inversions and stabilizes the atmosphere, thereby inhibiting pollution dispersal while ascending air destabilizes the air. Precipitation cleanses the troposphere both through scavenging (e.g. acid rain) in stratiform or convective precipitation and by ejecting pollutants into the stratosphere by deep convective storms (with a possible climatic effect). In clear air, pollution mixing near the ground is enhanced when solar heating is strong, but dispersion is inhibited during the night as long wave radiational cooling near the ground creates a low-level stable layer.

As suggested in the schematic represented by figure 1, pollutant dispersion potential is poorest in the polar regions during the winter. Not only is the region dominated by subsidence associated with the arctic surface high pressure system, but there is little or no solar heating. In contrast, pollutant dispersion is expected to be very efficient in the intertropical convergence zone where average ascent and strong solar heating during the day result in deep thunderstorm systems.

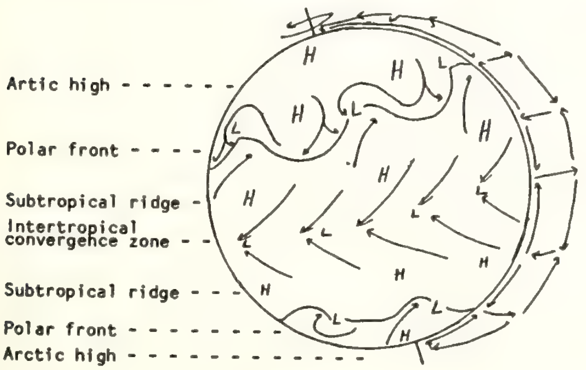

Figure 1.--Schematic of the general circulation of the earth in the northern hemisphere winter. There is average subsidence in the subtropical ridge and arctic high, and average ascent in the intertropical convergence zone and the polar front region.

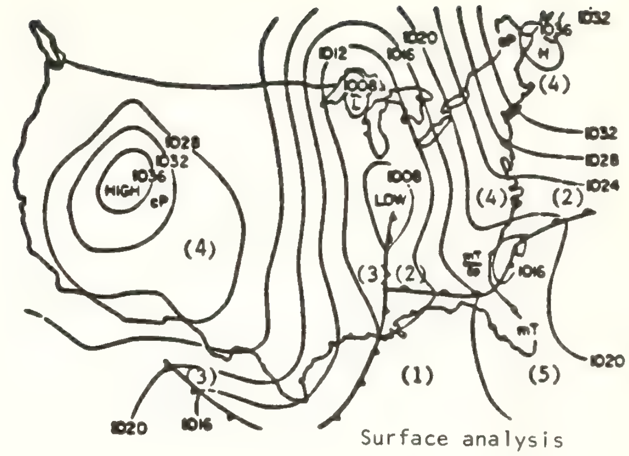

Figure 2.--Example of a surface analysis chart (for January 9, 1964) showing the application of the synoptic climatological model for the five synoptic classes listed in table 1 (reproduced from Pielke 1982).

From this brief discussion, it appears that certain areas of the world will be more prone to pollution problems than others.

Synoptic Classification

The United States, with the exception of Alaska, Hawaii and a number of territories is generally influenced by the southern portion of the arctic high, the polar front or the northern side of the subtropical ridge. Along the polar front propagate extratropical cyclones which have different air quality dispersion characteristics in different parts of the cyclone.

Figure 2 presents an example of a weather map where cold and warm fronts on the polar front are indicated. Five major synoptic categories are defined which have the general air pollution dispersion characteristics shown in figure 3. The reasons for these dispersion characteristics are summarized in tables 1 and 2. In the continental United States, category 4, the region corresponding to an equatorward bulge in the arctic high with sinking air through the lower and mid troposphere, has, in general, the poorest dispersion characteristics. When the sun angle is low (e.g. during the winter) and/or snow covers the ground, the dispersion under category 4 is even worse.

The frequency of occurrence of the different synoptic categories varies during the year and from location to location. Figure 4 illustrates the variation of these categories for Brownsville, Texas, Mobile, Alabama, and Hampton, Virginia. This data set was constructed from 10 years of weather maps (1955 to 1964, inclusive), with a 25 day running mean (Lindsey 1980; Garstang and others 1980).

Table 1.--Synoptic classification scheme (from Pielke 1982; modified from Lindsey)

Category	Air mass	Reason for categorization[a]
1	*mT*	*In the warm sector of an extratropical cyclone.* In this region the thickness and vorticity advection is weak with little curvature to the surface isobars. There is limited low level convergence with an upper level ridge tending to produce subsidence. Southerly low-level winds are typical
2	mT/cP, mT/cA, mP/cA	*Ahead of the warm front in the region of cyclonic curvature to the surface isobars.* Warm air advecting upslope over the cold air stabilizes the thermal stratification, while positive vorticity advection and low-level frictional convergence add to the vertical lifting. Because of the warm advection, the geostrophic winds veer with height. Low-level winds are generally north-easterly through south-easterly
3	*cP, cA*	*Behind the cold front in the region of cyclonic curvature to the surface isobars.* Positive vorticity advection and negative thermal advection dominate, with the resultant cooling causing strong boundary layer mixing. The resulting thermal stratification in the lower troposphere is neutral, or even slightly, superadiabatic. Gusty winds are usually associated with this sector of an extratropical cyclone. Because of the cold advection, the geostrophic winds back with height. Low-level winds are generally from the north-west through south-west
4	*cP, cA*	*Under a polar high in a region of anticyclonic curvature to the surface isobars.* Negative vorticity, weak negative thermal advection and low-level frictional divergence usually occur, producing boundary layer subsidence. Because of relatively cool air aloft, the thermal stratification is only slightly stabilized during the day, despite the subsidence. At night, however, the relatively weak surface pressure gradient associated with this category causes very stable layers near the ground on clear nights due to long-wave radiational cooling. The low-level geostrophic winds are usually light to moderate varying slowly from north-westerly to south-easterly as the ridge progresses eastward past a fixed location
5	*mT*	*In the vicinity of a subtropical ridge* where the vorticity and thickness advection, and the horizontal pressure gradient at all levels are weak. The large upper-level ridge, along with the anticyclonically curved low level pressure field, produces weak but persistent subsidence. This sinking causes a stabilization of the atmosphere throughout the troposphere. Low-level winds over the eastern United States associated with these systems tend to blow from the south-east through south-west

[a]This discussion applies to northern hemisphere.

The seasonal and geographic variation of the categories can be explained from the variations in the general circulation pattern. At Brownsville, for example, the much higher frequency of category 5 during the summer results because of the movement northward of the subtropical high. In the winter the polar front is farther south, so that polar highs reach the Brownsville area much more frequently. At the more northerly site of Hampton, the polar front is closer both summer and winter so that there is less variability in the pattern during the year.

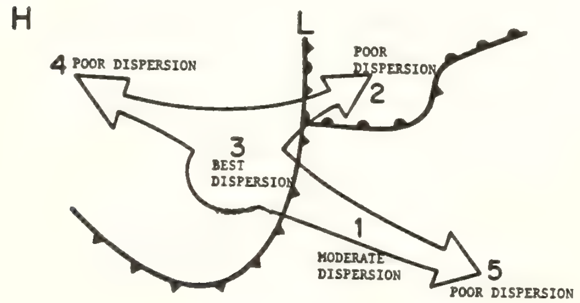

Figure 3.--Schematic illustration of the relative ability of different synoptic categories to disperse pollutants emitted near the ground. (from Pielke and others 1985).

Seasons can also be defined using the frequency of the categories. Winter is defined as that period of the year when a site has the highest frequency of categories which occur poleward of the polar front (i.e. categories 2, 3 and 4). Using this framework, summer corresponds to that time of the year when a location has the highest frequency of categories that lie equatorward of the polar front (i.e. categories 1 and 5). Spring and fall are the transition times when the categores poleward of the front are, respectively, decreasing or increasing in frequency. Using these meteorological definitions of seasons, despite the different latitudes of the cities in figure 4, the length of winter and summer and the time of commencement of spring and fall at the different locations are very similar (i.e. see fig. 5).

With these climatological definitions, the sensitivity of an area to air pollution degradation can be estimated. For the reasons listed in table 2, categories 2 and 4 are particularly prone to poor dispersion. In addition, since category 4 often lasts a relatively long time, as exemplified in the next paragraph, pollution often accumulates over time within a region.
It is possible to use the synoptic climatolgical classification scheme along with standard climatological classifications (e.g. see inside the

Table 2.--Overview of meteorological aspects of the 5 synoptic categories illustrated in figure 1 (northern Hemisphere). (Modified from Pielke and others 1985)

Category Characteristics	CATEGORY 1	2	3	4	5
category class	mT; In the warm sector of an extratropical cyclone	mT/cP, mT/cA, mP/cA; Ahead of the warm front in the region of cyclonic curvature to the surface	cP, cA; Behind the cold front in the region of cyclonic curvature to the surface isobars	cP, cA Under a polar high in a region of anticyclonic curvature to the surface	mT In the vicinity and west of a subtropical ridge
surface winds	brisk SW surface winds	light to moderate SE to ENE surface winds	strong NE to W surface winds	light and variable winds	light SE to SW winds
vertical motion	weakening synoptic descent as the cold front approaches	synoptic ascent due to warm advection and positive vorticity advection aloft	synoptic ascent due to positive vorticity advection aloft (in this region this ascent more than compensates for the descent due to cold advection)	synoptic descent (due to warm advection and/or negative vorticity advection aloft	synoptic subsidence (descending branch of the Hadley cell). Becomes stronger as you approach the ridge axis.
temperature advection	little temperature advection at the surface	warm advection above the frontal inversion	cold advection at the surface	weak temperature advection at the surface	weak temperature advection at the surface
inversion	Weak synoptic subsidence inversion caps planetary boundary layer	boundary layer capped by frontal inversion	deep planetary boundary layer	synoptic subsidence inversion and/or warm advection aloft create an inversion which caps the planetary boundary layer	synoptic subsidence inversion
diurnal variation in boundary layer stability	Moderate diurnal variability in the boundary layer stability	little diurnal variability in boundary layer stability because of cloud cover	little diurnal variability in the boundary layer stability because of strong winds and destabilizing of boundary layer by cold advection	In the absence of snow cover because of clear skies and light winds, large diurnal variability in boundary layer stability	moderate diurnal variability in boundary layer stability
diurnal variation in surface layer stability	Moderately unstable surface layer during the day moderately stable surface layer during the night	stably stratified surface layer day and night	near neutral surface layer day and night	weakly to moderately unstable surface layer during the day unless snow cover present or low sun angle in which case surface layer tends to be stably stratified. Very stable surface layer at night	moderately to strong unstable surface layer during the day moderate to strong stable surface layer during the night.
humidity	often humid in relative and absolute sense	often dry in absolute sense but humid in relative sense	dry in the absolute sense, usually dry in the relative sense	dry in the absolute sense humid in the relative sense at night/dry in relative sense during the day except when ground is snow-covered	humid in relative and absolute sense
cloud cover	clear to partly cloudy skies except near squall lines	mostly cloudy to cloudy	clear to scattered or broken shallow convective clouds	clear except tendency for fog at night	day: scattered fair weather cumulus night: clear [except near the mesoscale systems listed below]
dominate mesoscale systems	squall lines	embedded lines of convection	forced airflow over rough terrain systems; lake effect storms	mountain-valley flows land-sea breezes urban circulations (thermally-forced systems)	mountain-valley flows land-sea breezes urban circulations (thermally-forced systems)
precipitation types	organized lines of convective precipitation	often stable cloud types and precipitation. Overcast in general	medium to shallow depth convective clouds, showery precipitation	no precipitation	shallow convective clouds with deeper convective clouds and precipitation organized by thermally forced mesoscale systems such as listed above
ventilation	moderate to good ventilation	poor ventilation of low level (i.e., below frontal inversion) emissions	excellent ventilation	night or snow-covered ground: poor ventilation day: poor to moderate ventilation	day: moderate to good ventilation night: moderate to poor ventilation
deposition	dry deposition except wet deposition in showers	dominated by wet deposition	dry deposition except in showers	dry deposition	dry deposition except wet deposition in showers and thunderstorms
transport	long range	long range above inversion	long range	more local as you approach the center of the polar high	more local as you approach the center of the subtropical high

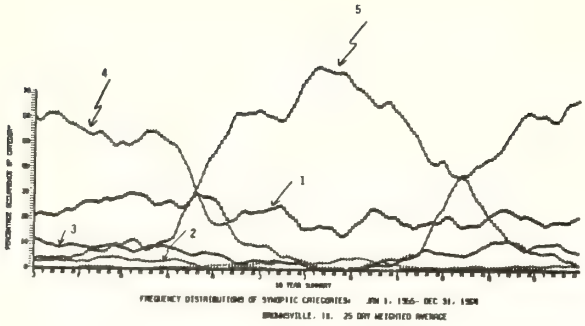

Figure 4a.--25 day average occurrence of synoptic categories for Brownsville, Texas. (From Lindsey 1980; Garstang and others 1980).

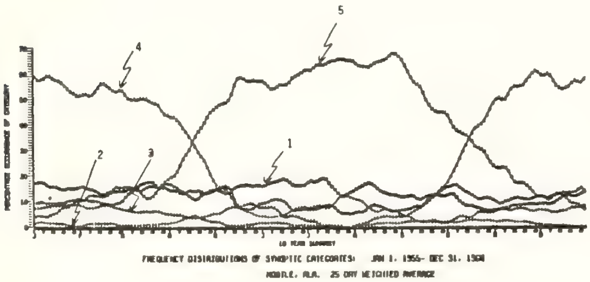

Figure 4b.--Same as figure 4a except for Mobile, Alabama. (From Lindsey 1980; Garstang and others 1980).

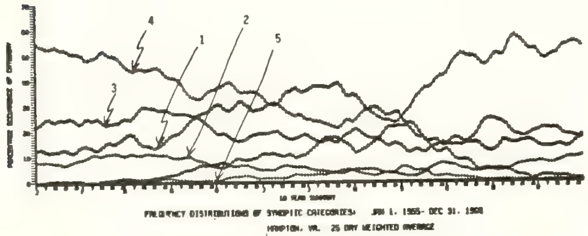

Figure 4c.--Same as figure 4a except for Hampton, Virginia. (From Lindsey 1980; Garstang and others 1980).

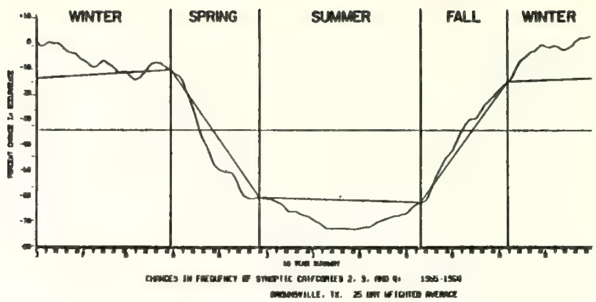

Figure 5a.--Changes in frequency of occurrence of catgories north of the polar front. (From Lindsey 1980; and Garstang and others 1980).

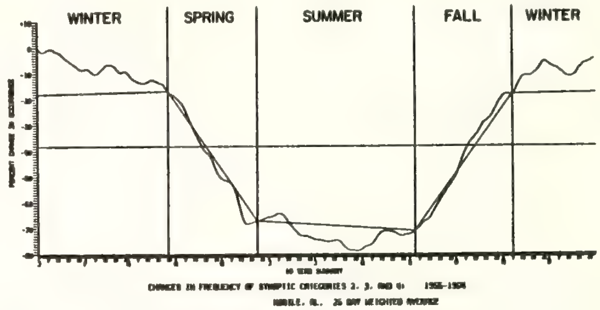

Figure 5b.--Same as figure 5a except for Mobile, Alabama. (From Lindsey 1980; Garstang and others 1980).

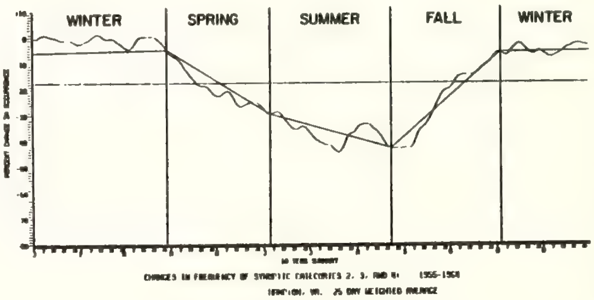

Figure 5c.--Same as figure 5a except for Hampton, Virginia. (From Lindsey 1980; Garstang and others 1980).

cover of Trewartha and Horn 1980) to characterize the annual and geographic variability in air quality dispersion characteristics over the United States.

In order to demonstrate the usefulness of this synoptic classification scheme, the study of air stagnation in the Lake Powell area reported in Pielke and others (1985) is used. In that investigation the occurrence of the different synoptic categories were evaluated for the October to May time periods of 1976 to 1981. Category 4, which, as has been discussed, is associated with poor air dispersion was evaluated for its persistence. During a persistent category 4 event (in which no other categories sweep through to flush out any pollution), air quality is likely to deteriorate if local sources of emission exist.

For the 5 year period of study, the average maximum duration was found to be 13.2 days with a maximum length of 18 days (fig. 6). In a separate study for western Colorado using radiosonde soundings at Grand Junction, Colorado, to characterize days with poor air quality dispersion, Hanson and McKee (1983) found similar results. In their study, during the December to January time period for 1959-1978, stagnation events lasted an average of 9 days with a maximum of 28 days in the 1976-1977 period. According to their study 3 days or longer occur on the average nearly 7 times per year. Pielke and others (1985) concluded that category 4 conditions correspond, in general, to the situations of persistent stagnation as found by Hanson and McKee (1983).

From the above discussions and the related published studies, it is concluded that the climatological potential for poor (or good) air quality dispersion can be characterized with reference to the general circulation of the earth and to synoptic weather systems. In the next section, tools will be discussed which can assess worst-case air quality impacts in complex terrain.

MESOSCALE ANALYSES

Types of Mesoscale Systems

There are a wide range of atmospheric systems as discussed, for example, in Pielke (1984), which are local in scale. These systems are referred to as being mesoscale in size. These include features which are associated with extratropical storms (e.g. squall lines, embedded convection) as well as circulations that are forced by terrain irregularities (e.g. land and sea breezes, mountain-valley winds). The latter type of systems, frequently referred to as thermally forced mesoscale systems are most often associated with polar and subtropical surface high pressure systems (i.e. synoptic categories 4 and 5), as listed in table 2.

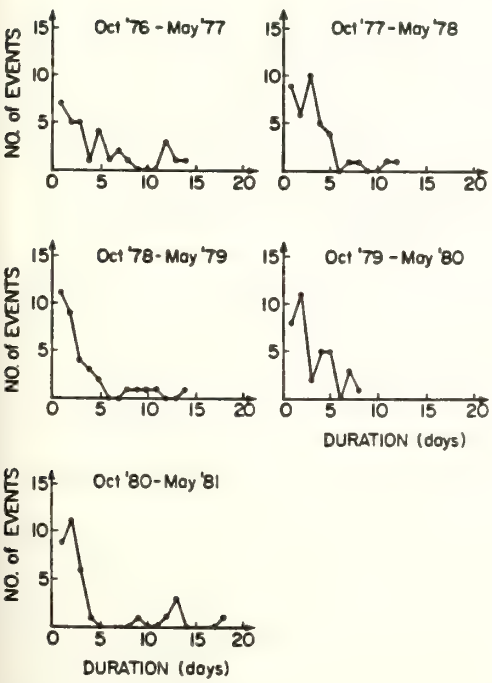

Figure 6.--Duration and number of events of category 4 for the specified periods. (From Pielke and others 1985)

Thermally-forced mesoscale circulations are most well developed when the synoptic flow is weak or absent, such as often occurs in category 4 and 5. Thermally-forced circulations develop because differential heating or cooling develops between adjacent locations. A wind circulation develops as the atmosphere seeks to reestablish equilibrium in the horizontal temperature distribution.

One type of thermally-forced system, the mountain-valley circulation, is particularly important in the air quality budget in irregular terrain. It is well-known that elevated topography acts as an elevated heat source during sunny days and as a heat sink on clear nights. The resultant wind flow is one in which air tends to move uphill during the day and downslope at night. This upslope/downslope flow tends to be confined to below the inversion height associated with the polar and subtropical high pressure systems. In rugged terrain, particularly in the winter and at times of low sun angles, this inversion is often confined below the heights of the higher terrain.

In the context of air quality degradation due to local sources of emission in irregular terrain during these meteorological situations, it is the potential for the accumulation of pollution in these mountain-valley circulations that is the greatest concern. This accumulation is expected to be greatest when the circulation is confined within a basin as a result of the pooling of cold air so that none of the effluent exits the region.

As discussed by T. B. McKee, (personal communication, 1984), State Climatologist of Colorado, there are two types of mountain-valley systems. A trapping valley system is one in which the mountain-valley circulation is too shallow for air to be transported out of the basin, whereas a flushing valley system is one in which gaps and passes exist below the inversion height so that the pooled cold air can flow out. A flushing valley, therefore, has a mechanism to disperse locally generated pollution.

The trapping valley, therefore, represents the potential for the worst case of pollution due to local sources within that valley. Unfortunately, <u>no existing regulatory air quality assessment tool is capable of estimating accumulations of air pollution within a trapping valley</u>. Moreover, even flushing valleys can act as a trapping valley if the synoptic wind flow is equal and opposite in direction to the outflow of cold air from the valley.

Algorithm to Estimate Air Quality Degradation due to Trapping

Despite the lack of attention by the regulatory agencies to trapping valleys, a very simple algorithm can be used to estimate potential or actual pollution impacts due to local sources within such a valley. This algorithm can be expressed as

$$C = Et/(\Delta x \Delta y \Delta z) \qquad (1)$$

where $\Delta x \Delta y \Delta z$ is the volume into which pollution is input at a rate of E over a time period t. The dimensions Δx and Δy could correspond to the horizontal dimensions of a valley, or to that portion of the valley over which the pollution spreads, while Δz would be the layer in the atmosphere into which the pollution is ejected. In a daytime, well-mixed boundary layer, this layer would correspond to the distance from the surface to the inversion height, whereas in a stable, stratified pool of cold air, this would correspond to some fraction of the inversion height. The time, t, would correspond to the length of time (i.e. persistence) of the trapped circulation, while E is the input of pollution above some baseline (which could be zero).

In order to illustrate the use of (1) to assess air quality impacts for a valley which acts to some extent as a trapping valley, the possible effects of a source in the Grand Valley of Colorado near Grand Junction on Colorado National Monument will be assessed for a typical wintertime stagnation event. The variables in (1) are defined as

$$\begin{aligned} \Delta z &= \beta z_i = 2\beta \text{km} && \beta \leq 1 \\ \Delta y &= 20\text{km} && \qquad (2) \\ \Delta x &= \alpha \Delta y && \alpha > 1 \\ t &= 9 \text{ days} \\ E &= 25 \text{ g s}^{-1} \text{ of } SO_2 \end{aligned}$$

In (2) β represents the fraction of the inversion height into which the pollution is input and diffused. The inversion height is estimated from the climatological analyses of Hanson and McKee (1983), and is below the elevation of the valley sides. The distance Δy is the approximate width of the valley, while α represents the distance of pollution dispersal along the valley with respect to the valley width. The time, t, of an episode is selected as 9 days based on the information discussed in the Air Quality Climatology section of this paper. E is a realistic estimate of SO_2 input from a relatively small industrial facility.

Using these values, (1) can be rewritten as

$$C(g/m^3) = \frac{(2.43 \times 10^{-5})}{\alpha\beta} \qquad (3)$$

The 24 hour primary air quality standard for SO_2 at a Class I area is expected to be the most sensitive to violation as a result of a 9 day stagnation event. The 24 hour standard is $5 \times 10^{-6} \text{g m}^{-3}$. Thus (3) indicates a violation if the volume covered by $\Delta x \Delta y \Delta z$ includes a Class I area and $\alpha\beta < 5$.

Colorado National Monument has been categorized as a state equivalent to a Federal Class I area for SO_2. The state nomenclature refers to it as a Category I area. Thus depending on the values of α and β, and the site of the emission with respect to the Monument, a violation could be shown to exist.

Table 3 illustrates values of C for different values of α and β. In a stable layer of pooled air, it is expected that β would be on the order of 10 percent of the inversion height since a surface non-buoyant emission would tend to be confined close to the ground while an elevated release would stabilize around the effective stack height as long as it remains below the inversion. The along valley direction for the example is more difficult to estimate, however, but a distance of 200 km (α = 10) is likely to represent the largest horizontal area covered.

Local Versus Long Range Transport

The discussion in the last section focused on a situation in which only local recirculation and accumulation of pollution is important. In the more general case, transport of pollution into a region is of concern.

Using the synoptic classification scheme presented earlier, it is qualitatively straightforward to argue that long-range transport becomes important when a significant synoptic flow exists. The synoptic flow in the lower troposphere can be estimated from the 850 mb and 700 mb winds, and from the surface pressure gradient. A unidirectional wind of 10 knots (5 ms^{-1}) at 850 mb, for example, would transport a plume of pollution 240 miles (384 km) after 24 hours. A wind of 30 knots (15 ms^{-1}) would result in a movement of 720 miles (1152 km).

Table 3.--Selected solutions for (3) for various values of α and β

		α =	
	C	1	0.1
β =	10	$2.43 \times 10^{-6} \text{gm}^{-3}$	$2.43 \times 10^{-5} \text{gm}^{-3}$
	20	$1.21 \times 10^{-6} \text{gm}^{-3}$	$1.21 \times 10^{-5} \text{gm}^{-3}$

Table 4.--Selected applications of a mesoscale model to characterize local wind flows and air quality dispersion characteristics

Sea- and/or Land-Breeze		
Pielke, 1974a	south Florida	qualitative validation
Cotton and others 1976	south Florida	qualitative validation
Gannon, 1976	south Florida	qualitative validation
Pielke & Mahrer, 1978	south Florida	quantitative validation
Simpson and others 1979	south Florida	quantitative validation
McCumber, 1980	south Florida	qualitative validation
Segal & Pielke, 1981	Chesapeake Bay region	quantitative validation
Segal and others 1982a	Chesapeake Bay region	quantitative validation
Mizzi, 1982	coastal Oregon	qualitative validation
Mizzi & Pielke, 1983	coastal Oregon	qualitative validation
Lyons and others 1979a,b	southern Lake Michigan	qualitative validation
Okeyo, 1982	Kenya	qualitative validation
Segal and others 1982d	Israel	qualitative validation
Segal and others 1982e	Israel	quantitative validation
Segal and others 1983a	Israel	qualitative validation
Segal and others 1983d	Israel	qualitative validation
Segal and others 1983b	Egypt	sensitivity study
Segal and others 1985	Israel	qualitative validation
Abbs, 1984	southern Victoria, Australia	qualitative validation
Garratt & Physick, 1985	northern Australia	qualitative validation
Diab & Garstang, 1984	South Africa	qualitative validation
Islands/Cities		
Mahrer & Pielke, 1976	Barbados	qualitative validation
Hjelmfelt, 1980	St. Louis	qualitative validation
Hjelmfelt, 1982	St. Louis	qualitative validation
Dalu & Cima, 1983	Sardinia	qualitative validation
Lake Effect		
Hjelmfelt & Braham, 1982	southern Lake Michigan	qualitative validation
Snow, 1981	Delmarva peninsula and adjacent waters	quantitative validation
Forced Airflow Over Rough Terrain		
Mahrer & Pielke, 1978b	idealized mountain range (2-D simulation)	validation against results of a different mountain flow model
Low-Level Jet		
McNider & Pielke, 1981	Great Plains	qualitative comparison
McNider and others 1982a	Texas coast	qualitative comparison
Mountain-Valley Flows		
McNider, 1981	idealized three-dimensional valley	qualitative agreement with classic conceptual flow in a mountain-valley
McNider & Pielke, 1984	Colorado	qualitative validation

While winds are seldom so uniform, using these relative estimates of the influence of wind speed on transport, it is straightforward to suggest that pollution releases near regions of moderate or strong synoptic flow will be subject to long range transport, while lighter synoptic flow will result in less movement and a greater importance of local circulations.

Near the centers of the synoptic categories 4 and 5 (the polar and subtropical highs) are regions with light synoptic flow, while a larger horizontal pressure gradient force, and thus stronger synoptic winds occur near extratropical cyclones. Current tools used to assess transport (e.g. the ARL-ATAD model; see Artz 1982), apply observational data to characterize transport. Unfortunately, however, due to insufficient measurement data density, these tools are only able to characterize, to some extent, the longer range transport, but not the movement of air associated with local circulations. Table 2 summarizes whether long or local range transport dominates for each of the synoptic categories.

Use of a Mesoscale Model to Characterize Local Circulations

Since the existing synoptic observation network is unable to characterize local circulations, such as occur in synoptic categories 4 and 5, other techniques must be found. In lieu of an extensive measurement network in a local area, however, the only tools available are models. In this section, one such tool will be discussed.

Since the early 1970's, extensive research has been made into the study of thermally-forced mesoscale systems by our research group (see table 4). With respect to the impact of local circulations on air quality and local transport under synoptic categories 4 and 5, this mesoscale meteorological has been used to simulate wind flow and turbulence characteristics in complex terrain. The output of this model is used to integrate a so-called Lagrangian Particle Dispersion (LPD) model in which releases of a number of particles from elevated or surface locations are used to simulate the dispersion of pollution from actual or planned sources. This dispersion is a result of both turbulent diffusion and differential vertical and horizontal advection. Our approach has been summarized recently in Pielke and others (1983).

To illustrate this approach with respect to an existing federally legislated Wilderness area, the meteorological model has been integrated in order to simulate the local flows that developed on July 18, 1977 in and near Shenandoah National Park, Virginia. About 79,000 acres of the Park are legislated Wilderness. Figure 7 illustrates the local wind flow at 3.5 m as predicted by the model. The output from the meteorological model is used to simulate a hypothetical release from an elevated source near

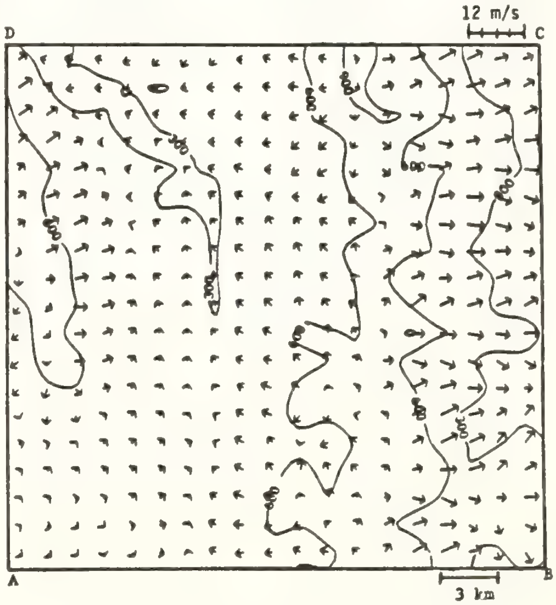

Figure 7.--Simulated horizontal wind velocities at 3.5 m height on July 18, 1977 at 0310 LST. Contours indicate elevation of terrain in meters. The top of the figure is towards the northeast (from Pielke and others 1985).

Elkton, Virginia (figure 8). This location corresponds to the planned site of a brewery. Existing EPA-approved regulatory tools indicated that the Class I increment for SO_2 would not be violated at any point within the Park. The results in figure 8, however, raise serious questions as to the accuracy of the EPA approved results since the recirculation (and resultant accumulation) of pollution associated with the mountain-valley flow illustrated in figure 7 were ignored in the regulatory models. Additional work is continuing under National Park sponsorship to quantify expected concentration impacts on the Park Wilderness areas as a result of the mountain-valley circulation, however, it appears that to some extent at least, Shenandoah Valley is acting as a trapping valley.

CONCLUSIONS

Using a straightforward synoptic climatological analysis scheme, it is shown that the potential for an area to experience air quality degradation due to local sources is highest under polar and subtropical highs. With respect to polar highs, the problem is most severe when the sun angle is low and snow covers the ground, and the polar high persists for a long period of time.

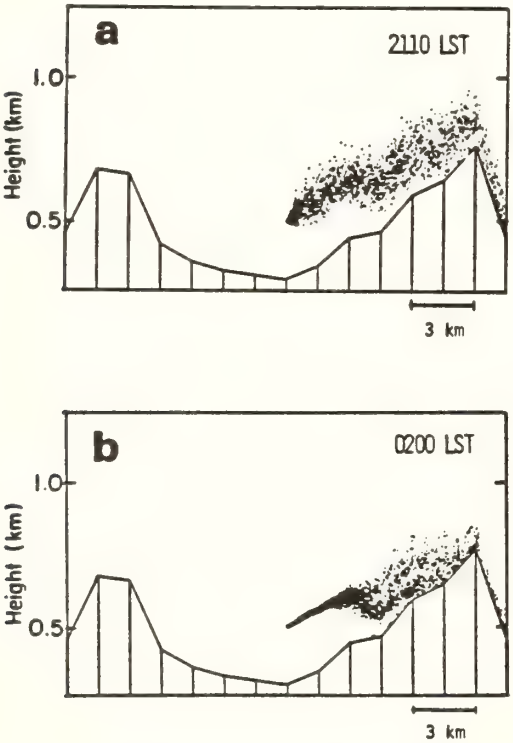

Figure 8.--(a) Plot showing dispersion of particles continuously released at 60 second time intervals during 2 hours following sunset on July 18, 1977. Release height is 200 m above ground level; (b) same as (a) except for release during the two hour period following midnight. The meteorological model applied to create figure 7 was used to generate these dispersion characteristics.

A simple algorithm is introduced which is designed to estimate worst case impact in a trapping valley. The potential for the accumulation of air pollution in such valleys due to the persistence of a polar high in a region is ignored in current regulatory air quality assessments. Trapping valleys and synoptic flow stagnation often occur in wilderness areas.

Refined air quality assessments are shown to be possible using a mesoscale meteorological model and a pollution dispersion model. These tools permit quantitative assessments of pollution build-up from local sources as a result of the recirculation of the local air. This tool, along with the synoptic climatological classification scheme, also permits an evaluation of the fractional contribution of long range versus local sources in the air quality degradation in a region. Areas near the center of a polar or subtropical surface high pressure system, for instance, appear to be dominated by local sources, if they exist, whereas in the vicinity of extratropical cyclones, long range transport is usually much more important.

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REFERENCES

Abbs, Deborah J. Observations and numerical modelling of southern Australian sea breezes. Melbourne, Australia: University of Melbourne; 1984. 307 p. Ph.D. dissertation.

Artz, Richard Scott. Comparison of methods of air parcel trajectory analysis for defining source-receptor relationships. Charlottesville, VA: University of Virginia; 1982. 363 p. M.S. thesis.

Cotton, William R.; Gannon, P. T.; Pielke, Roger A. Numerical experiments on the influence of the mesoscale circulations on the cumulus scale. Journal of the Atmospheric Sciences. 33: 252-261; 1976.

Dalu, G. A.; Cima, A. Three-dimensional air flow over Sardinia. Il Nuovo Cimento. (in press); 1983.

Diab, R. D.; Garstang, Michael. Assessment of wind power ptoential for two constrasting coastlines of South Africa using a numerical model. Journal of Climate and Applied Meteorology. 23: 1645-1659; 1984.

Everhart, W. C. The national park service. Boulder, CO; Westview Press; 1983. 197 p.

Gannon, Patrick T. On the influence of surface thermal properties and clouds on the south Florida sea breeze. Coral Gables, Florida: University of Miami; 1976. 152 p. Ph.D. dissertation.

Garratt, John R.; Physick, William L. The inland boundary layer at low latitudes: II sea-breeze influences. Boundary Layer Meteorology. 29: 209-232; 1985.

Garstang, Michael; Nnaji, S.; Pielke, Roger A.; Gusdorf, J.; Lindsey, Charles; Snow, J. W.; Coastal zone wind energy, part I. Synoptic and mesoscale controls and distributions of coastal wind energy. Charlottesville, VA: University of Virginia; 1980; DOE Contract DE-AS06-76ET20274.

Hanson, K. R.; McKee, Thomas B. Potential for regional air pollution episodes in Colorado. Atmospheric Science Paper No. 375. Fort Collins, CO: Colorado State University, Dept. of Atmospheric Science; 1983.

Hjelmfelt, Mark R. Numerical simulation of the effects of St. Louis boundary layer airflow and convection. Chicago, IL: University of Chicago; 1980. Ph.D. dissertation.

Hjelmfelt, Mark R. Numerical simulation of the effects of St. Louis on mesoscale boundary layer airflow and vertical air motion: simulations of urban vs. non-urban effects. Journal of Applied Meteorology. 21: 1239-1257; 1982.

Hjelmfelt, Mark R.; Braham, R. R. Numerical simulation of the airflow over Lake Michigan for a major lake effect snow event. Monthly Weather Review. 111: 205-219; 1983.

Lindsey, Charles Grattan. Analysis of coastal wind energy regimes. Charlottesville, VA: University of Virginia; 1980. 183 p. M.S. thesis.

Lyons, Walter A.; Schuh, Jerome A.; McCumber, Michael. Comparison of observed mesoscale lake breeze wind fields to computations using the University of Virginia Mesoscale Model. In: Proceedings, 4th symposium on turbulence, diffusion, and air polution; Reno, Nevada; 1979a: 572-575.

Lyons, Walter A.; Schuh, Jerome A.; Keen, C. S.; McCumber, Michael; McNider, Richard T. Trajectory observations compared to computations using a regional mesoscale model to study air pollution in a lake breeze. In: Proceedings, 72nd annual meeting of the Air Pollution Control Association; Cincinnati, Ohio; 1979b: 79-15.3, 22 p.

Mahrer, Ytzaq; Pielke, Roger A. The numerical simulation of the airflow over Barbados. Monthly Weather Review. 104: 1392-1402; 1976.

Mahrer, Ytzaq; Pielke, Roger A. A test of an upstream spline interpolation technique for the advective terms in a numerical mesoscale model. Monthly Weather Review. 106: 818-830; 1978b.

McCumber, Michael C. A numerical simulation of the influence of heat and moisture fluxes upon mesoscale circulations. Charlottesville, VA: University of Virginia; 1980. 255 p. Ph.D. dissertation.

McKee, Thomas B. Personal communication. Fort Collins, CO: Department of Atmospheric Science, Colorado State University; 1984.

McNider, Richard T. Investigation of the impact of topographic circulations on the transport and dispersion of air pollutants. Charlottesville, VA: University of Virginia; 1981. 210 p. Ph.D. dissertation.

McNider, Richard T.; Pielke, Roger A. Diurnal boundary layer development over sloping terrain. Journal of the Atmospheric Sciences. 38: 2198-2212; 1981.

McNider, Richard T.; Pielke, Roger A. Numerical simulation of slope and mountain flows. Journal of Climate and Applied Meteorology. 10: 1441-1453; 1984.

McNider, Richard T.; Anderson, K. J.; Pielke, Roger A. Numerical simulation of plume impaction. In: AMS proceedings of the 3rd conference on application of air pollution meteorology; 1982 January; San Antonio, Texas; 1982a.

Mizzi, Arthur P. A numerical invesigation of the mesoscale atmospheric circulation in the Oregon coastal zone with a coupled atmosphere ocean model. Charlottesville, VA: University of Virginia. M.S. thesis.

Mizzi, Arthur P.; Pielke, Roger A. A numerical study of the mesoscale atmospheric cirulation observed during a coastal upwelling event on August 23, 1972. Part I: sensitivity studies. Monthly Weather Review. 112: 76-90; 1983.

Okeyo, A. E. A two-dimensional model of the lake-land and sea-land breezes over Kenya. Nairobi, Kenya: University of Nairobi, P.O. Box 30107; 1982. 244p. M.S. thesis.

Pielke, Roger A. A three dimensional numerical model of the sea breeze over south Florida. Monthly Weather Review. 102: 115-134; 1974a.

Pielke, Roger A. Mesoscale meteorological modeling. New York; Academic Press; 1984. 612 p.

Pielke, Roger A.; Mahrer, Ytzaq. Verification analysis of the University of Virginia three-dimensional mesoscale model prediction over south Florida for July 1, 1973. Monthly Weather Review. 106: 1568-1589; 1978.

Pielke, Roger A.; McNider, Richard T.; Segal, Moti; Mahrer, Ytzhaq. The use of a mesoscale numerical model for evaluations of pollutant transport and diffusion in coastal regions and over irregular terrain. Bulletin of the American Meteorological Society. 64: 243-249; 1983.

Pielke, Roger A.; Yu, C-H.; Arritt, Raymond W.; Segal, Moti. Mesoscale air quality under stagnant conditions. Proceedings, air pollution effects on parks and wilderness areas conference; 1985 May 20-23; Mesa Verde National Park, CO.

Segal, Mordecay; Pielke, Roger A. Numerical model simulation of biometeorological heat load conditions - summer day case study for the Chesapeake Bay area. Journal of Applied Meteorology. 20: 735-749; 1981.

Segal, Mordecay; McNider, Richard T.; Pielke, Roger A.; McDougal, D. S. A numerical model simulation of the regional air pollution meteorology of the Greater Chesapeake Bay area - summer day case study. Atmospheric Environment. 16: 1381-1397; 1982a.

Segal, Mordecay; Mahrer, Ytzaq; Pielke, Roger A. Numerical model study of wind energy characteristics over heterogeneous terrain - central Israel case study. Boundary Layer Meteorology. 22: 373-392; 1982d.

Segal, Mordecay; Mahrer, Ytzaq; Pielke, Roger A. Application of a numerical mesoscale model for the evaluation of seasonal persistent regional climatological patterns. Journal of Applied Meteorology. 21: 1754-1762; 1982e.

Segal, Mordecay; Mahrer, Ytzaq; Pielke, Roger A. A numerical model study of meteorological patterns associated with a lake confined by mountains - the Dead Sea case. Quarterly Journal of the Royal Meteorological Society. 109: 549-564; 1983a.

Segal, Mordecay; Pielke, Roger A.; Mahrer, Ytzaq. On climatic changes due to a deliberate flooding of the Qattara depression (Egypt). Climatic Change. 5: 73-83; 1983b.

Segal, Mordecay; Mahrer, Ytzaq; Pielke, Roger A. On some meteorological patterns at the Dead Sea area during advective sharav situations. Israel Journal of Earth Science. 33: 76-83; 1983d.

Segal, Mordecay; Mahrer, Ytzaq; Pielke, Roger A.; Kessler, Robert C. Model evaluation of the summer daytime induced flows over southern Israel. Israel Journal of Earth Science. 34: 39-46; 1985.

Simpson, J.; Westcott, N. E.; Clerman, R. J.; Pielke, R. A. On cumulus mergers. Arch. Met. Geogh. Biokl., Ser. A.; 1979.

Snow, Joseph W. Coastal zone wind power assessment. Charlottesville, VA: University of Virginia; 1981. 244 p. Ph.D. dissertation.

Trewartha, G. T.; Horn, L. H. An introduction to climate. McGraw-Hill Book Company; 1980. 416 p.

RANKING WILDERNESS AREAS FOR SENSITIVITIES AND RISKS TO AIR POLLUTION

J. P. Bennett, M. K. Esserlieu and R. J. Olson

ABSTRACT: Wilderness areas may be compared for sensitivity to air pollutants by ranking the sum of the numbers of plant species sensitive to SO_2 and O_3, and weighted by the relative abundances of each species used in the summation. This ranking can be coupled with actual ambient air quality data for each wilderness area using a geographic information data base to determine the ranking of the wilderness area most at risk to air pollution. Using these procedures, the National Park Service has determined that out of 11 parks for which there is adequate data, Saguaro National Monument, Great Smoky Mountains, Shenandoah, and Rocky Mountain National Parks are experiencing the greatest risk of air pollution damage to vegetation from O_3 and SO_2 occurring simultaneously.

INTRODUCTION

If wilderness areas are exposed to air pollutants and acidic precipitation, the resources that are directly affected and which we are most concerned about are biological organisms. Plants and animals are directly affected through gas exchange mechanisms and surface deposition. Research on air pollution effects on vegetation has been performed for at least 100 years and has clearly established that plants are on average an order of magnitude more sensitive to SO_2 and O_3 than animals. It appears reasonable to conclude that studying the vegetation of wilderness areas would be a good approach to assessing the sensitivities of wilderness areas overall.

Why do we want to assess the sensitivities of wilderness areas? Federal land managers of these areas are faced with decisions to be made almost daily regarding issues and actions that may affect wilderness resources. Permits for new sources of pollution near the areas, changes in state air quality plans, and power plant expansions are just a few examples of such actions. In addition, the allocation of limited funds to projects must be guided by where the greatest needs are. All these activities would benefit from knowledge of which wilderness areas are most sensitive and most exposed to air pollutants. The approach described herein provides a methodology for generating this kind of information.

Certain wilderness areas are designated Class I under the Clean Air Act for protection against significant deterioration of air quality. The National Park Service (NPS) is responsible for 48 of these Class I areas (not all of which are officially designated wilderness areas) (table 1). Since all of these areas contain prime examples of major ecosystems, it became important to determine which were the most sensitive to O_3 and SO_2, the most phytotoxic air pollutants prevalent today. The method chosen was modeled after that used by Klopatek and others (1981) for ranking Forest Service RARE II tracts.

METHODS

Data Sources

Plant species and abundances.--The definition of dominant and common vascular plants used in this study is all trees and tree-sized shrubs, plus other shrubs and grasses that are significant within their habitats in the parks. Although this definition is not strict, its purpose was to ensure that the most widespread and commonly occurring vascular species were included in the analysis; no more rigorous definition is implied. The tree and large-shrub species were identified by the NPFLORA Data Base (Bennett 1982). Nonarboreal species names (shrubs, grasses, and forbs) were obtained from park naturalists, botanists, and other scientists most familiar with the flora of each park. These scientists were also requested to identiy species that in their opinion met the criteria of importance or significance within the park habitats and to estimate each species abundance in the park. Park superintendents were asked to request appropriate staff to rank species abundances as common, intermediate, or rare. These abundances are based primarily on their distribution within their common habitats, but also relative to all other species. Species lists and abundances compiled for each park are available in Esserlieu and Olson (1985). For this study the number

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Table 1.--Air quality Class I parks, locations and areas

Park	State	Park area in hectares
Acadia National Park	Maine	15,634
Arches National Park	Utah	22,035
Badlands National Park	South Dakota	26,001
Bandelier National Monument	New Mexico	9,416
Big Bend National Park	Texas	216,062
Black Canyon National Monument	Colorado	4,524
Bryce Canyon National Park	Utah	8,709
Canyonlands National Park	Utah	105,279
Capitol Reef National Park	Utah	72,728
Carlsbad Caverns National Park	New Mexico	12,282
Chiricahua National Monument	Arizona	3,820
Crater Lake National Park	Oregon	49,534
Craters of the Moon National Monument	Idaho	17,500
Denali National Park and Preserve	Alaska	784,885
Everglades National Park	Florida	557,819
Glacier National Park	Montana	375,366
Grand Canyon National Park	Arizona	493,059
Grand Teton National Park	Wyoming	46,865
Great Sand Dunes National Monument	Colorado	13,537
Great Smoky Mountains National Park	North Carolina/Tennessee	158,030
Guadalupe Mountains National Park	Texas	18,960
Haleakala National Park	Hawaii	7,798
Hawaii Volcanoes National Park	Hawaii	49,817
Isle Royale National Park	Michigan	53,370
Joshua Tree National Monument	California	173,889
Lassen Volcanic National Park	California	31,963
Lava Beds National Monument	California	23,035
Mammoth Cave National Park	Kentucky	21,095
Mesa Verde National Park	Colorado	3,278
Mount Rainier National Park	Washington	85,267
North Cascades National Park	Washington	213,128
Olympic National Park	Washington	348,895
Petrified Forest National Park	Arizona	20,339
Pinnacles National Monument	California	5,241
Point Reyes National Seashore	California	10,267
Redwood National Park	California	44,121
Rocky Mountain National Park	Colorado	97,058
Saguaro National Monument	Arizona	28,895
Sequoia-Kings Canyon National Parks	California	303,793
Shenandoah National Park	Virginia	31,978
Theodore Roosevelt National Park	North Dakota	11,774
Virgin Islands National Park	Virgin Islands	5,952
Voyageurs National Park	Minnesota	88,678
Wind Cave National Park	South Dakota	11,449
Yellowstone National Park	Idaho/Montana/Wyoming	1,251,676
Yosemite National Park	California	261,427
Zion National Park	Utah	48,813

of species ranged between 148 in Great Smoky Mountains to nine in Petrified Forest. This large variation represents differences primarily in park species diversities, but also in individual interpretaions by park staffs and in completeness of the parks' floras. Overall, 940 different species were included in this study (table 2).

Sensitivities of natural vegetation.--Data sources presenting original research results as well as those comparing results of other researchers were combined to determine species sensitivities to SO_2 and O_3. A compilation of open literature sources from the NPS provided most of the references (Bennett, personal communication). In general, these sensitivities were based on laboratory and field experiments with visible foliar injury as the measured parameter. Although visible injury is not always associated with growth reductions, it has been the most commonly reported test result. Nearly one-third of the 940 selected species occurring in the parks have been tested for tolerance to either SO_2 or O_3 or both pollutants (table 2). Sensitivity classifications were "sensitive", "intermediate", "resistant", and "unknown"

Table 2.--Numbers of species used to determine vulnerabilities of each park by pollutant

Park	Vascular Plant Species: SO_2 Sensitivity Studied	Vascular Plant Species: O_3 Sensitivity Studied	Vascular Plant Species: Total Used in Study	Lichens: SO_2 Sensitivity studied	Lichens: Total Used in Study
Acadia	38	20	59	44	136
Arches	34	10	77	1	12
Badlands	22	9	42	*	*
Bandelier	40	16	83	*	*
Big Bend	27	8	135	27	201
Black Canyon	16	7	17	*	*
Bryce Canyon	35	11	60	*	*
Canyonlands	41	14	88	*	*
Capitol Reef	16	5	26	*	*
Carlsbad Caverns	17	7	54	*	*
Chiricahua	15	5	39	6	192
Crater Lake	15	9	35	5	41
Craters of the Moon	8	4	10	*	*
Denali	8	5	30	*	*
Everglades	6	3	110	*	35
Glacier	38	13	64	10	89
Grand Canyon	31	10	63	14	87
Grand Teton	18	8	29	1	17
Great Sand Dunes	28	11	53	3	8
Great Smoky Mountains	67	42	148	43	301
Guadalupe Mountains	23	9	63	*	*
Isle Royale	20	12	31	97	489
Joshua Tree	8	0	56	*	*
Lassen Volcanic	20	10	33	*	*
Lava Beds	25	12	42	*	*
Mammoth Cave	49	37	118	*	*
Mesa Verde	26	9	46	13	45
Mount Rainier	18	5	35	15	132
North Cascades	38	11	55	2	34
Olympic	22	5	37	26	172
Petrified Forest	4	0	9	*	*
Pinnacles	2	1	15	*	*
Point Reyes	11	5	35	*	*
Redwood	16	6	39	13	32
Rocky Mountain	19	7	38	28	348
Saguaro	19	7	61	*	*
Sequoia-Kings Canyon	31	14	96	26	73
Shenandoah	65	44	132	35	189
Theodore Roosevelt	14	7	21	36	208
Voyageurs	25	17	35	75	404
Wind Cave	24	11	46	6	35
Yellowstone	15	5	23	6	49
Yosemite	17	13	34	5	57
Zion	35	13	64	24	168

Indicates numbers of species for which sensitivity was known and total species in the data sets for vascular species and lichens used in this study. Asterisks in the lichen columns indicated the lichen flora is virtually unknown.

and were estimated from reported experimental results. The master list of species sensitivities and references appears in Esserlieu and Olson (1985). When references conflicted over the sensitivity rating, preference was shown for more recent studies and chronic exposure levels. If neither criteria pertained, then the more sensitive classification was used. Erring in favor of the resource was preferred to understating sensitivity.

Sensitivities of lichens.--The sensitivities of lichens to SO_2 was also used as an indicator of the vulnerability of Class I parks. Wetmore (1983) reported on lichen species found in 42 of the Class I parks and their estimated sensitivities to SO_2. For this study, the lichen species found in the parks were summarized according to: (1) Wetmore's five SO_2 sensitivity classifications; (2) different species known to occur in a park; (3) completeness of lichens surveys; and (4)

the number of type locales for specimens originally described from that park. The five SO_2 sensitivity classifications (sensitive, sensitive to intermediate, intermediate, intermediate to resistant, and resistant) are based on literature reports of laboratory experiments and field observations. Lichen species data pertain to the area within park boundaries except for the North Casades National Park, which is characterized by data for immediately adjacent lands.

Sulfur dioxide data.--In this study, air quality data for SO_2 are based on monitoring data from the U.S. Environmental Protection Agency (EPA) for the years 1977 to 1982. Sulfur dioxide data are from monitors within 50 and 100 km of the park centroid because dispersion from tall stacks and certain atmospheric conditions may result in elevated SO_2 levels at these distances. The average annual arithmetic mean values in micrograms per cubic meter (ug/m^3) are reported in table 3. The only station to report

Table 3.--Air quality data for SO_2 and O_3 for 44 Class I National Parks

	Park	SO_2 Annual Average 50 km	SO_2 Annual Average 100 km	O_3 7-mo 7-h Average
		(Micrograms per cubic meter)		
1	Acadia	3.59	22.59	71.2
2	Arches	0.00	4.29	*
3	Badlands	0.00	2.96	84.5
4	Bandelier	0.00	6.65	92.6
5	Big Bend	*	*	75.7
6	Black Canyon	*	*	*
7	Bryce Canyon	0.00	8.99	97.5
8	Canyonlands	0.00	4.29	98.1
9	Capitol Reef	*	*	97.9
10	Carlsbad Caverns	0.00	11.24	82.4
11	Chiricahua	0.00	53.58	100.4
12	Crater Lake	0.00	13.09	63.1
13	Craters of the Moon	*	*	96.5
14	Denali	*	*	*
15	Everglades	3.77	7.24	*
16	Glacier	2.65	0.00	*
17	Grand Canyon	8.29	0.00	92.2
18	Grand Teton	*	*	*
19	Great Sand Dunes	*	*	96.9
20	Great Smoky Mountains	13.98	32.07	91.2
21	Guadalupe Mountains	*	*	82.4
22	Isle Royale	*	*	*
23	Joshua Tree	2.74	4.23	103.3
24	Lassen Volcanic	*	*	96.3
25	Lava Beds	0.00	13.09	56.7
26	Mammoth Cave	5.73	32.53	78.8
27	Mesa Verde	0.00	24.41	*
28	Mount Rainier	0.00	41.03	51.0
29	North Cascades	*	*	50.4
30	Olympic	62.15	41.03	50.8
31	Petrified Forest	*	*	101.6
32	Pinnacles	3.09	0.00	84.3
33	Point Reyes	5.49	12.56	77.7
34	Redwood	*	*	55.1
35	Rocky Mountain	0.00	33.92	85.7
36	Saguaro	9.96	88.80	100.0
37	Sequoia-Kings Canyon	*	*	109.0
38	Shenandoah	0.00	40.23	87.1
39	Theodore Roosevelt	2.86	3.88	*
40	Voyageurs	3.55	3.95	*
41	Wind Cave	2.50	2.96	84.5
42	Yellowstone	0.00	2.50	*
43	Yosemite	*	*	101.0
44	Zion	8.99	0.00	97.5

All SO_2 data are for 1977-1982 and O_3 data are for 1980. Asterisks indicate no data available. Park numbers are used in figures 4 - 11.

exceedances of the National Ambient Air Quality Standard of 80 ug/m^3 annual average for SO_2 was Tucson, AZ, 9 km from Saguaro National Monument, in 1980 and 1981. Values of more than 30 ug/m^3 were reported from stations 42 to 81 km from eight parks: Chiricahua, Creat Smoky Mountains, Mammoth Cave, Mount Rainier, Olympic, Rocky Mountain, Saguaro, and Shenandoah.

Ozone data.--The ozone values are 7-hour daylight mean concentrations in micrograms per cubic meter (ug/m^3) for the seven-month period, April through October, 1980 (table 3). Ozone data were obtained from the EPA SAROAD (Storage and Retrieval of Aerometric Data) data base. Stations were selected to minimize the influence of high readings associated with urban areas; approximately 360 stations had appropriate data for 1980. Daily averages were calculated as the average concentration between the hours of 0900 and 1600 local standard time. The statistical technique of "kriging" was employed to estimate grid values from the irregularly spaced monitoring stations. Ozone values were not estimated for points that did not have data from at least five monitoring stations within 500 km or one station within 30 km. Values for each park were estimated for the half-degree cell in which the park centroid fell.

Ranking Methods

Selected plant species for each park were used to assess potential sensitivity and actual risk. Data were collected, sensitivity ratings were tabulated for each of these species for each park, abundances of the species were estimated, and parks were ranked based on combinations of these data. The three Class I tropical parks outside the conterminous United States (Haleakala, Hawaii Volcanoes, and Virgin Islands) were not analyzed because of inadequate knowledge of their floras and their sensitivities to air pollution. Sequoia and Kings Canyon National Parks, which are adjacent and have similar floras, are treated as one park for this study. Thus a total of 44 parks were used in this analysis.

Limitations of data and method.--Although the best data available were used, limitations of the analysis should be recognized. First, definitions of sensitivities of species vary with testing methods and the researcher's individual assessments. Second, knowledge about species sensitivities in the parks varies substantially. For some parks, sensitivities of a very small percentage of species have been tested, but for others a large portion of species have been tested. Table 2 compares the numbers of species studied for air pollution sensitivity with the total number of species for each park used in this study. The ranking method used in this study considers only the sensitivities of species whose responses have been tested; the ratio of species with known sensitivities to the total number in the park is used only to define reliability, but is not used in the ranking itself. A third limitation is the lack of lichen data for all parks. Although 44 parks are ranked based on sensitivity of vascular plant species, only 25 parks are ranked based on sensitivity of lichen species. In calculating overall ranks, only 22 parks had data for more than three species of lichens.

Approach.--Several types of rankings were performed which determined the relative potential sensitivities of the parks, and the parks most at risk from detrimental impacts of air pollution. Each ranking combined species sensitivities and relative abundances to produce overall values. The values are produced by weighting common, intermediate, and rare species (3, 2, and 1, respectively, 1 for unknown abundances), and similarly weighting sensitive, intermediate, and resistant species (3, 2, and 1, respectively, 0 if unknown). Thus, common sensitive species were given the greatest weight in this analysis. These sensitivity and abundance values were multiplied, summed for all species in the park, then divided by the total number of species for which sensitivities are known to determine the sensitivity value of a park (see Equation 1). If a species sensitivity was unknown, that species did not contribute to the summation. This step was repeated for each pollutant and for lichens and all three were summed to produce an overall value of park vegetation sensitivity. The value will hereafter be referred to as vulnerability since it combines sensitivities and abundances.

$$V_p = \frac{\sum_{x=1}^{n} S_x A_x}{k} + \frac{\sum_{y=1}^{n} O_y A_y}{l} + \frac{\sum_{z=1}^{n} l_z}{m} \quad (1)$$

$$(V_p = V_{so_2} + V_{o_3} + V_l)$$

where: V_p = vulnerability of a park;
S = SO_2 sensitivity of a vascular species (0-3);
O = ozone sensitivity of a vascular species (0-3);
A = abundance of a vascular species (1-3);
L,l = lichen SO_2 sensitivity (0-3);
n = number of species in the park;
k,l = number of vascular plants for which SO_2 or O_3 sensitivity is known; and
m = number of lichen species for which SO_2 sensitivity is known.

When lichen sensitivities were unknown or not available, the V_p value was not calculated. The vulnerabilities were then ranked from low to high and assigned sequential numbers from 1 to 44 or 25 depending on the analysis. The data that are presented are these pure rank values and not the actual vulnerability values themselves. The lowest number values represent the most vulnerable parks.

The final stage in the analysis consisted of coupling the sensitivity ranks of the parks with the ambient air quality data. By comparing the parks that were most sensitive with the air pollutant concentrations, the parks that were most at risk to air pollution effects could be identified.

RESULTS

Vulnerabilities of Parks

Data on park vegetation vulnerabilities to air pollution are of interest individually, but are also valuable for management purposes when they indicate one park's tolerance relative to another's. These data allow only for qualitative and comparative rankings between parks in this study. Since the original data vary significantly in quality and completeness, even these relative ranks should be used cautiously. Nevertheless, estimates of relative vulnerabilities of the parks are useful. Although numeric values are assigned for purposes of ranking, no quantitative significance is implied or inferred, and none should be assumed. No absolute importance should be assigned to the position of one park relative to another. We recommend comparing park vulnerabilities roughly in groups of four or more.

Summary of park ranks.--An overall summary of park ranks appears in table 4. This table summarizes potential vulnerabilities only and

Table 4.--Ranks of park vulnerabilities based on values calculated in Equation 1

Park	Vascular Plants SO_2	Vascular Plants O_3	Vascular Plants $SO_2 + O_3$	Lichens	Vascular Plants + Lichens
Acadia	11.0	19.0	14	7	2
Arches	34.0	38.0	39	17	19
Badlands	39.0	25.5	35	*	*
Bandelier	37.0	28.0	32	*	*
Big Bend	41.0	42.0	43	13	23
Black Canyon	24.0	13.0	17	*	*
Bryce Canyon	40.0	30.5	38	*	*
Canyonlands	21.0	35.0	25	*	*
Capitol Reef	31.0	24.0	24	*	*
Carlsbad Caverns	30.0	29.0	26	*	*
Chiricahua	23.0	36.0	28	15	16
Crater Lake	27.5	17.0	20	3	14
Craters of the Moon	26.0	12.0	18	*	*
Denali	2.0	6.5	3	*	*
Everglades	43.0	33.5	41	*	*
Glacier	8.0	11.0	10	14	3
Grand Canyon	17.0	8.5	11	9	8
Grand Teton	19.0	14.0	12	25	20
Great Sand Dunes	42.0	37.0	42	17	24
Great Smoky Mountains	20.0	15.0	15	5	7
Guadalupe Mountains	36.0	25.5	30	*	*
Isle Royale	4.0	8.5	5	10	1
Joshua Tree	5.0	*[1]	37	*	*
Lassen Volcanic	12.5	6.5	9	*	*
Lava Beds	33.0	32.0	33	*	*
Mammoth Cave	1.0	3.0	1	*	*
Mesa Verde	44.0	39.0	44	22	25
Mount Rainier	38.0	27.0	34	2	21
North Cascades	32.0	30.5	31	23	22
Olympic	29.0	23.0	23	4	15
Petrified Forest	25.0	*[1]	40	*	*
Pinnacles	12.5	40.5	27	*	*
Point Reyes	15.0	40.5	29	*	*
Redwood	35.0	33.5	36	8	18
Rocky Mountain	7.0	1.0	4	19	5
Saguaro	3.0	2.0	2	*	*
Sequoia-Kings Canyon	14.0	5.0	8	12	6
Shenandoah	22.0	22.0	21	6	12
Theodore Roosevelt	6.0	10.0	7	17	4
Voyageurs	18.0	20.0	19	11	9
Wind Cave	10.0	21.0	16	24	17
Yellowstone	27.5	18.0	22	1	10
Yosemite	9.0	4.0	6	21	11
Zion	16.0	16.0	13	20	13

[1]No ozone response data available.

is not related in any way to ambient air pollution concentrations. Parks that had the same vulnerabilities were given the same ranks using an averaging algorithm.

Ten most and least vulnerable parks.--For discussion purposes it is easier to shorten the ranking lists to the ten most and least vulnerable parks, shown in table 5. Each column in this table corresponds to the same column in the previous table, but lists the ten most vulnerable in descending order and the ten least vulnerable in ascending order. The first three columns are based on 44 parks in the analysis and the last two columns are based on 25 parks.

Vulnerability based on vascular plant sensitivities to SO_2.--Parks that are most vulnerable to SO_2 are quite varied and geographically dispersed from the eastern U.S. to Alaska. The most sensitive are Mammoth Cave, Denali, Saguaro, and Isle Royale. The least sensitive parks are equally diverse and include Mesa Verde, Everglades, Great Sand Dunes, and Big Bend. Seven out of ten of the least sensitive parks are primarily arid desert type ecosystems.

Vulnerability based on vascular plant sensitivities to O_3.--Because the sensitivities of natural vegetation to O_3 are less well known than for SO_2, the O_3 vulnerability of parks is based on less data. For two parks, Joshua Tree and Petrified Forest, no data on plant sensitivities to O_3 were available. Contrary to expectations, most of the parks in the top ten are in the western U.S., and only two parks, Isle Royale and Mammoth Cave, are in the eastern U.S. The O_3 vulnerabilities of Acadia, Shenandoah, and Great Smoky Mountain can be seen in table 4. With one exception (Everglades), most of the parks in the least vulnerable top ten are in the western U.S.

Vulnerability based on vascular plant sensitivities to SO_2 and O_3.--The twenty parks most and least vulnerable to both pollutants are very similar to those vulnerable to SO_2 alone, indicating the predominance of sensitivity to this pollutant in the analysis. Mammoth Cave, Saguaro, Denali, Rocky Mountain, and Isle Royale are the most vulnerable parks to SO_2 and O_3 combined, while Mesa Verde, Big Bend, Everglades, and Great Sand Dunes are the least vulnerable.

Table 5.--Twenty most and least air pollutant vulnerable National Parks

	Vascular Plants			Lichens	
	SO_2	O_3	$SO_2 + O_3$	Alone	With Vascular Plants
	MOST VULNERABLE PARKS IN DESCENDING ORDER				
Most	Mammoth Cave	Rocky Mountain	Mammoth Cave	Yellowstone	Isle Royale
	Denali	Saguaro	Saguaro	Mount Rainier	Acadia
	Saguaro	Mammoth Cave	Denali	Crater Lake	Glacier
	Isle Royale	Yosemite	Rocky Mountain	Olympic	Theo. Roosevelt
	Joshua Tree	Sequoia-Kings Cnyn.	Isle Royale	Gt. Smoky Mtns.	Rocky Mountain
	Theo. Roosevelt	Denali)	Yosemite	Shenandoah	Sequoia-Kings Cnyn.
	Rocky Mountain	Lassen Volcanic)	Theo. Roosevelt	Acadia	Gt. Smoky Mtns.
	Glacier	Isle Royale)	Sequoia-Kings Cnyn.	Redwood	Grand Canyon
	Yosemite	Grand Canyon)	Lassen Volcanic	Grand Canyon	Voyageurs
Least	Wind Cave	Theo. Roosevelt	Glacier	Isle Royale	Yellowstone
	LEAST VULNERABLE PARKS IN ASCENDING ORDER				
Least	Mesa Verde	Big Bend	Mesa Verde	Grand Teton	Mesa Verde
	Everglades	Petrified Forest)	Big Bend	Wind Cave	Gt. Sand Dunes
	Gt. Sand Dunes	Pinnacles)	Gt. Sand Dunes	North Cascades	Big Bend
	Big Bend	Mesa Verde	Everglades	Mesa Verde	North Cascades
	Bryce Canyon	Arches	Petrified Forest	Yosemite	Mount Rainier
	Badlands	Gt. Sand Dunes	Arches	Zion	Grand Teton
	Mount Rainier	Chiricahua	Bryce Canyon	Rocky Mountain	Arches
	Bandelier	Canyonlands	Joshua Tree	Arches)	Redwood
	Guadalupe Mtns.	Redwood)	Redwood	Gt. Sand Dunes)	Wind Cave
Most	Redwood	Everglades)	Badlands	Theo. Roosevelt)	Chiricahua
BASED ON		44 PARKS		25 PARKS	

Brackets indicate parks with equal ranks.

Vulnerability based on lichen sensitivities to SO_2.--The parks most and least vulnerable based on lichen sensitivities to SO_2 are quite different from those vulnerable based on vascular plants, probably due to the fewer number of parks in the analysis. Only one park, Isle Royale, appears in both most vulnerable lists and two, Mesa Verde and Great Sand Dunes appear in both least vulnerable lists. The most and least vulnerable parks appear to be dominated again by western parks. In addition, two parks, Yellowstone and Grand Teton, which are adjacent to one another, came out most and least vulnerable respectively. This was due to the appearance of a common sensitive lichen in Yellowstone but not in Grand Teton, which is probably due to inadequate knowledge of the Grand Teton lichen flora and not the actual absence of the species from the park. This fluke in the analysis, in addition to it being based on only 25 parks, suggests that its usefulness is limited.

Vulnerability based on both vascular plant and lichen sensitivities.--This list of the top ten most vulnerable parks, which is the most inclusive of sensitive plants, is different from the list based just on vascular plants sensitive to SO_2 and O_3. Several parks, including Acadia, Great Smoky Mountains, Sequoia-Kings Canyon, and Glacier appear on the list. Mammoth Cave, however, does not because there is no published lichen flora yet for the park. Those parks least vulnerable, however, are very similar to those based on vascular plant sensitivies, indicating that vascular plant sensitivities determine park vulnerabilities when the species are quite tolerant.

Relationship between SO_2 and O_3 vulnerability ranks.-- A useful relationship to examine for cross-vulnerability would be the one between SO_2 and O_3 ranks. This is shown in figure 1 and illustrates that most parks are equally vulnerable to both pollutants. Parks are identified in this and all subsequent graphs by the numbers which are in column one in table 3. Eleven parks, Saguaro, Mammoth Cave, Rocky Mountain, Yosemite, Denali, Isle Royale, Glacier, Theodore Roosevelt, Lassen Volcanic, Sequoia-Kings Canyon, and Grand Canyon are all highly vulnerable to both pollutants. Four parks, however, depart somewhat from this relationship in that they are highly vulnerable to SO_2 but not to O_3: Joshua Tree, Pinnacles, Petrified Forest, and Point Reyes. No parks appeared to be highly vulnerable to O_3 alone and not SO_2.

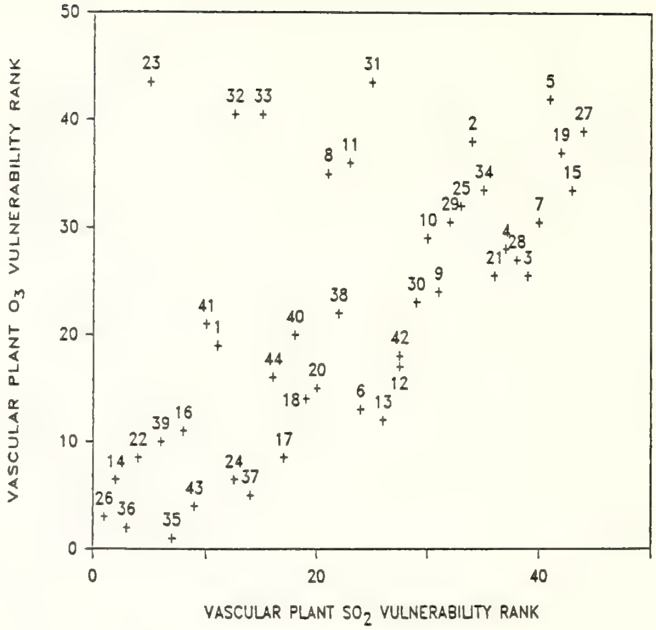

Figure 1.--Scattergram of SO_2 and O_3 vulnerability ranks of 44 national park units based on vegetation sensitivities. Park ranks are shown by their positions along the x and y axes. Numbers near each point (+ symbol) are park codes and are given in table 3.

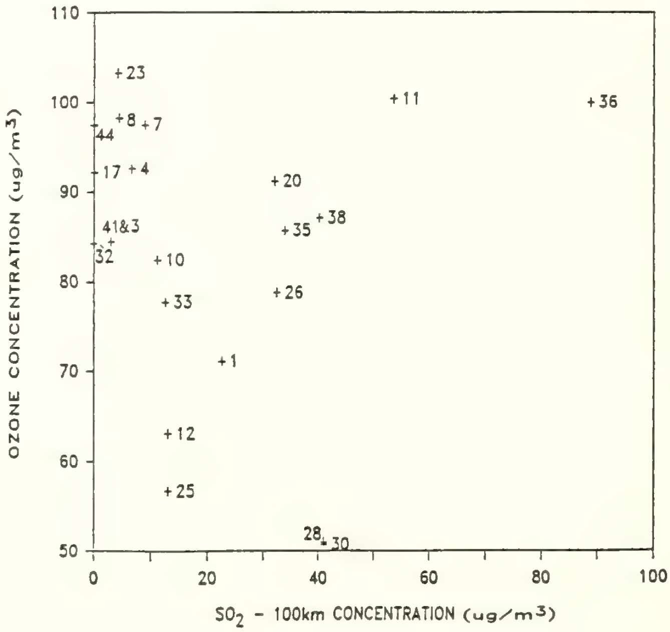

Figure 2.--Scattergram of measured SO_2 and O_3 concentrations at monitoring stations proximate to 22 national park units. Sources for these concentrations are given in the text. Parks not indicated on this figure did not have paired monitoring data to be included. Park codes are given in table 3.

Parks at Risk

Relationship between SO_2 and O_3 concentrations in parks.--Figure 2 shows a plot of the O_3 and 100 km SO_2 concentrations for the 22 parks that have such paired data. As expected, no significant correlation occurs between the two pollutants in this graph (nor with the 50 km

SO_2 data). What we are interested in determining, however, is whether or not there are any parks with high values for both pollutants, i.e. parks that are located in the upper right portion of the graph. It is worth noting that about six parks are found in this area of the graph: Saguaro, Chiricahua, Shenandoah, Mammoth Cave, Great Smoky Mountains, and Rocky Mountain. The subsequent analysis will compare parks (with air pollution data) that are vulnerable and are experiencing high levels of pollutants.

Risk Assessment.--Assessment of parks at risk can be performed most easily using a graphical technique. By plotting the air quality concentration for each park against its respective sensitivity ranking a graph of parks at risk is generated. A schematic drawing of this plot is shown in figure 3. We call the entire plot the probability of injury occurring in national park units. Parks that are experiencing high pollutant concentrations and have high vulnerability rankings are probably experiencing current pollution effects, while those with low concentrations and vulnerability rankings may experience injury in the future. Each plot (analysis) is based on slightly different numbers of parks (75% to 25% of the total of 44) because of missing air pollution data (table 3). In general, the fewer parks in the analysis, the less useful it is. Seven such plots, roughly in order of decreasing number of parks, are presented below.

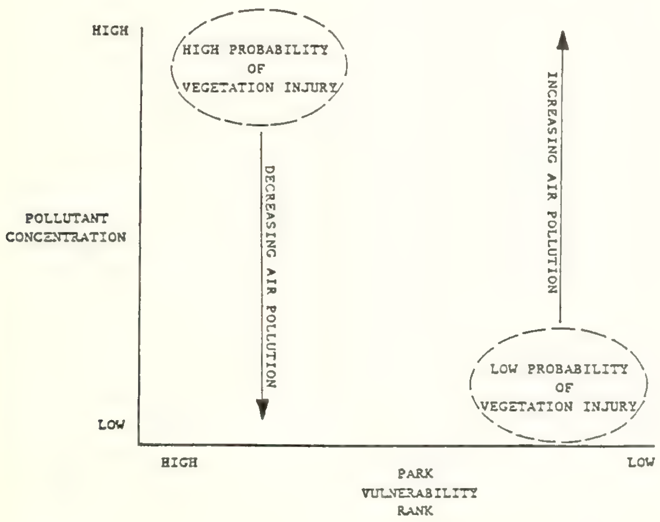

Figure 3.--Conceptual plot of probability of vegetation injury in national parks. Each park pollutant concentration is plotted against the parks vulnerability rank. Parks appearing in the lower right quadrant have low probabilities of vegetation injury while those in the upper left quadrant have high probabilities of vegetation injury. Parks appearing elsewhere in the plot have intermediate probabilities. As air pollution increases or decreases in a park, the probability of vegetation injury moves along the trajectories shown by the two arrows.

Vascular Plants - SO_2 - 50 km.--Twenty-nine parks have SO_2 data representing them to be included in this and the next analysis. Only one park, Olympic, appears to be near high SO_2 concentrations (>60 ug/m^3) (fig. 4). Since it has a low vulnerability rank, however, it probably has an intermediate chance of experiencing current injury. Parks with high vulnerabilities may be experiencing levels of SO_2 below 20 ug/m^3.

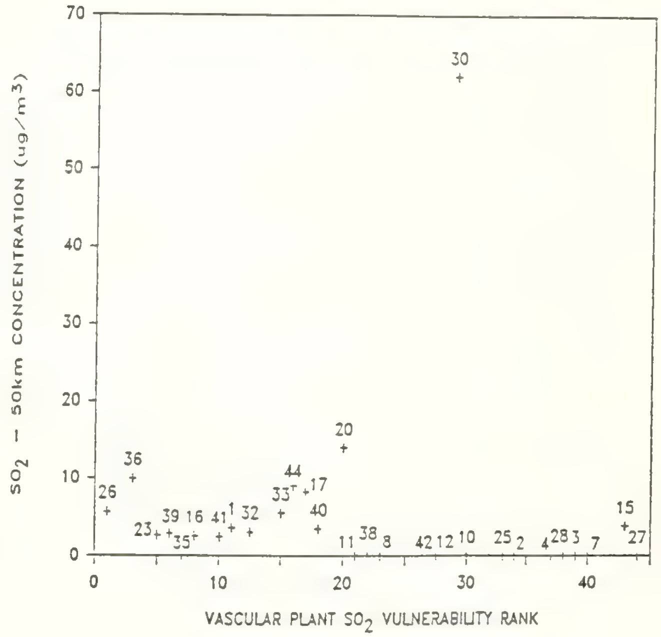

Figure 4.--Scattergram of measured SO_2 concentrations (ug/m^3) at monitoring stations within 50 km of 29 parks and park SO_2 vulnerability ranks based on SO_2 sensitivities of vascular plants. Park codes are given in table 3.

Vascular Plants - SO_2 - 100 km. Five parks, Saguaro, Shenandoah, Chiricahua, Olympic, and Mt. Rainier are potentially experiencing high SO_2 concentrations according to monitors at this distance (fig. 5), with the first three ranked in roughly the upper half of the vulnerability rankings. Those three parks may be experiencing current SO_2 plant injury. Six more parks, Mammoth Cave, Rocky Mountain, Acadia, Olympic, Mount Rainier, and Great Smoky Mountains, are potentially being exposed to SO_2 values >20 ug/m^3 and are highly ranked, suggesting they may experience SO_2 injury in the near future.

Vascular Plants - O_3.--Of the 33 parks included in this analysis, many more could be experiencing high concentrations of pollutant (O_3) than those in the SO_2 analysis (fig. 6). Eight parks, Saguaro, Yosemite, Sequoia-Kings Canyon, Lassen, Craters of the Moon, Great Smoky Mountains, Grand Canyon, and Zion could all be experiencing O_3 concentrations >90 ug/m^3 and are highly ranked, while Rocky Mountain, Mammoth Cave, Shenandoah, and Wind Cave are highly ranked (upper 50th

percentile) and just below this value. Eight more parks are above this O_3 value but are ranked low in vulnerability.

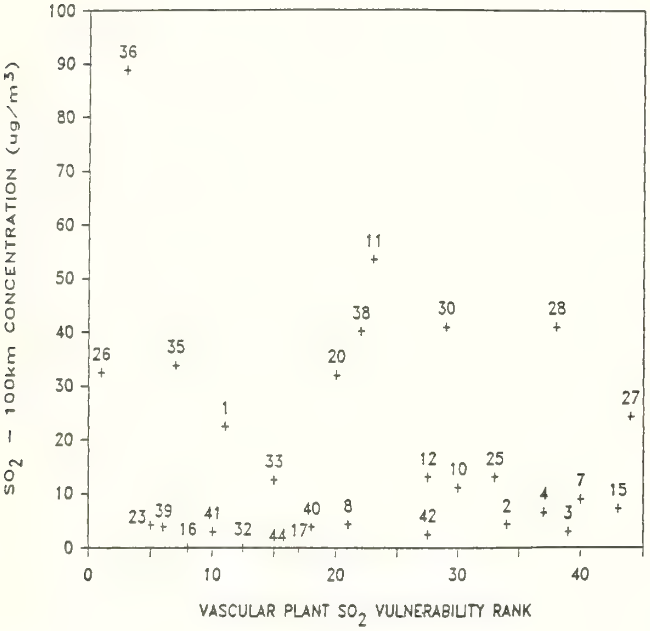

Figure 5.--Scattergram of measured SO_2 concentrations (ug/m^3) at monitoring stations within 100 km of 29 parks and park SO_2 vulnerability ranks based on SO_2 sensitivities of vascular plants. Park codes are given in table 3.

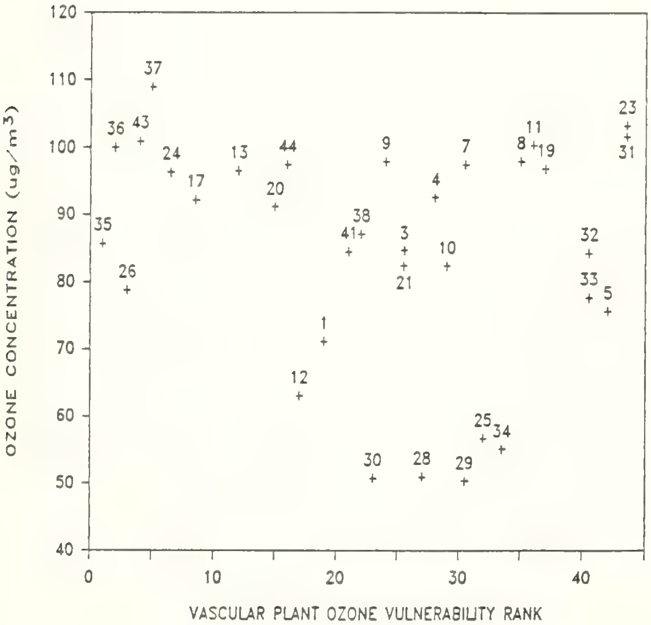

Figure 6.--Scattergram of measured O_3 concentrations (ug/m^3) at monitoring stations near 33 parks and park O_3 vulnerability ranks based on O_3 sensitivities of vascular plants. Park codes are given in table 3.

Vascular Plants - SO_2 + O_3. This assessment is shown with a pseudo-three-dimensional graph using different symbols for different levels of the third variable. In these two examples, one each for SO_2 at 50 and 100 km, SO_2 is the variable plotted with different symbols. Only 22 park units with both SO_2 and O_3 value are plotted. Parks with a high certainty of current injury would have to meet three criteria: high vulnerability rank, and both high SO_2 and O_3 values. Virtually no parks meet these criteria using the 50 km SO_2 values (Olympic has a low vulnerability rank) (fig. 7), but with the 100 km SO_2 data, Saguaro, Rocky Mountain, Great Smoky Mountains, Mammoth Cave, and Shenandoah do (fig. 8). These parks are probably experiencing the greatest injury on vascular plants currently from both SO_2 and O_3. Chiricahua appears to be near high SO_2 and O_3 monitoring stations, but has a low vulnerability rank.

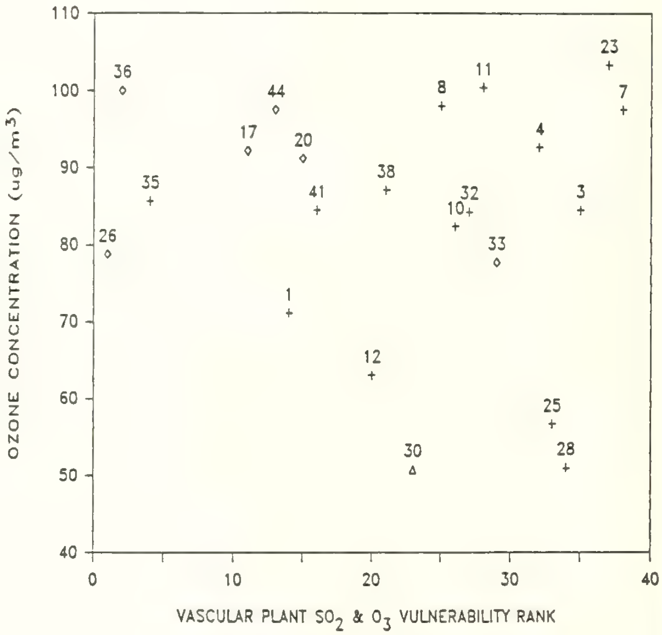

Figure 7.--Scattergram of measured O_3 concentrations and 50 km SO_2 concentrations (both in ug/m^3) for 22 parks and park vulnerability ranks based on combined SO_2 and O_3 sensitivities of vascular plants. Park codes are given in table 3. SO_2 values >16 ug/m^3 (> mean + + one standard deviation) are indicated by a triangle; values between 5 and 16 ug/m^3 (mean $\pm$ o standard deviation) by a diamond; and values <5 ug/m^3 (<mean - one standard deviation) by a plus symbol.

Lichens - SO_2 - 50 km. Using just lichens as indicators of SO_2 vulnerability, 17 parks qualified for risk analysis using SO_2 data. Olympic National Park shows extreme risk to current effects because it is high ranked and is experiencing high SO_2 values (fig. 9). Most other parks have low values using stations at this distance.

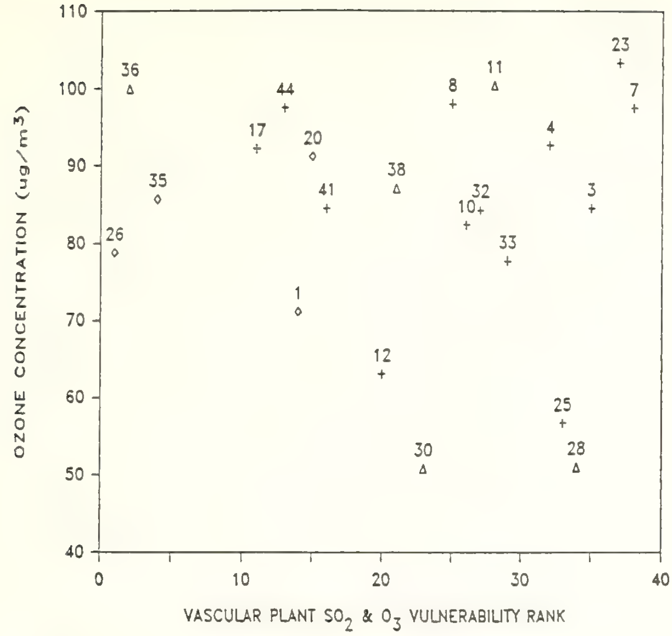

Figure 8.--Scattergram of measured O_3 concentrations and 100 km SO_2 concentrations (both in ug/m^3) for 22 parks and park vulnerability ranks based on combined SO_2 and O_3 sensitivities of vascular plants. Park codes are given in table 3. SO_2 values >38 ug/m^3 (> mean + one standard deviation) by a triangle; values between 18 and 38 ug/m^3 (mean ± one standard deviation) by a diamond; and values <18 ug/m^3 (<mean - one standard deviation) by a plus symbol.

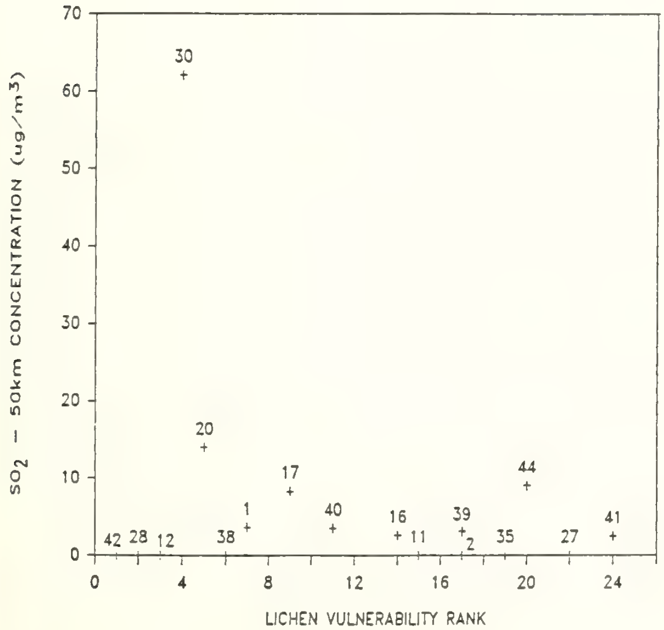

Figure 9.--Scattergram of measured SO_2 concentrations (ug/m^3) at monitoring stations within 50 km of 17 parks and park vulnerability ranks based on SO_2 sensitivities of lichens. Park codes are given in table 3.

Lichens - SO_2 - 100 km. Using stations within 100 km adds four more parks to the list of parks at risk to lichen effects: Mount Rainier, Shenandoah, Acadia and Great Smoky Mountains (fig. 10). Lichen effects due to SO_2 in these parks may occur at a later time than in Olympic due to more distant sources, as evidenced by additional monitoring stations between 50 and 100 km.

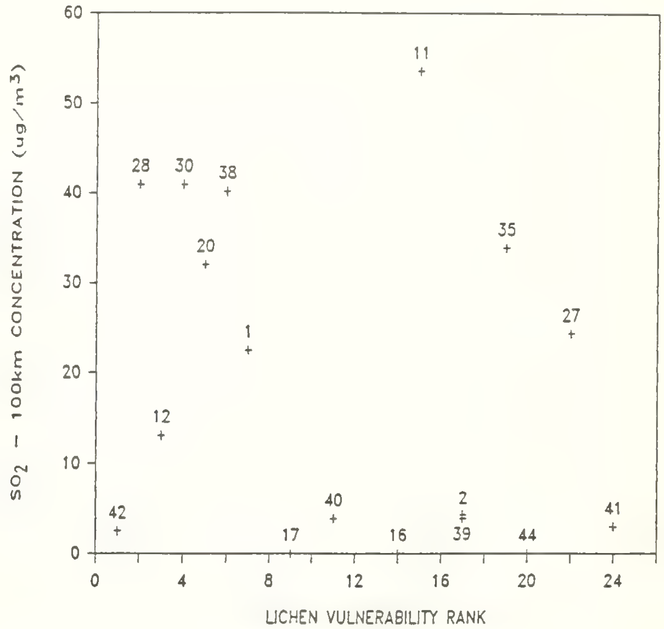

Figure 10.--Scattergram of measured SO_2 concentrations (ug/m^3) at monitoring stations within 100 km of 17 parks and park vulnerability ranks based on SO_2 sensitivities of lichens. Park codes are given in table 3.

Vascular Plants + Lichens - SO_2 + O_3. This may be considered the most important assessment since it includes vulnerabilities based on both vascular plants and lichens, and park units containing both SO_2 and O_3 values. However, out of the 44 class I parks in the study, only 11 parks have data to make the assessment (fig. 11). Thus the usefulness of this assessment is somewhat limited. Using the 100 km SO_2 values, Shenandoah, Great Smoky Mountains Acadia, and Rocky Mountain appear to be most at risk to current effects on vascular plants and lichens from both SO_2 and O_3.

DISCUSSION

No study is worthwhile unless it can be validated in some fashion. In this particular study an easy way to test its validity is to verify if parks that are at high risk are actually experiencing air pollution injury to vegetation and conversely, if parks at low risk are not showing any injury. If a number of parks at low risk are showing some injur then it would suggest the analysis is faulty.

Parks that are currently experiencing foliar injury on vascular plant vegetation from O_3 include Mammoth Cave, Shenandoah, Great Smoky

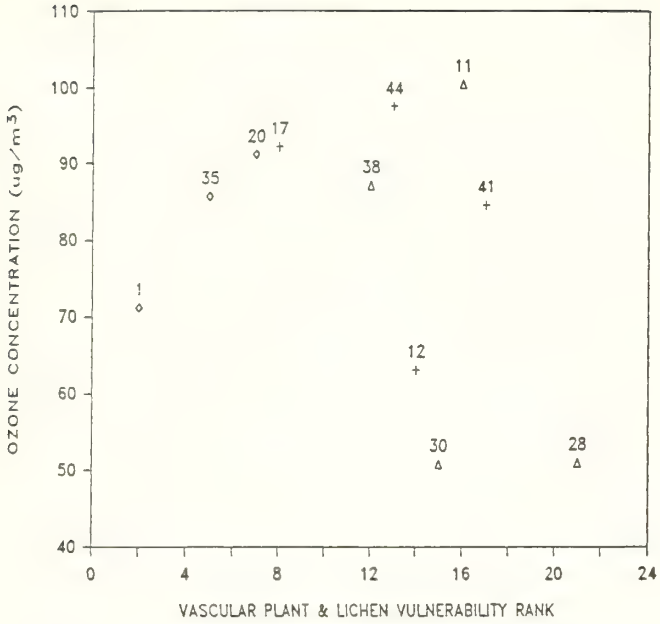

Figure 11.--Scattergram of measured O_3 concentrations and 100 km SO_2 concentrations (both in ug/m^3) for 11 parks and park vulnerability ranks based on combined SO_2 sensitivities of lichens and SO_2 and O_3 sensitivities of vascular plants. Park codes are given in table 3. SO_2 symbols are the same as in figure 8.

Mountains, Sequoia-Kings Canyon, Acadia, Saguaro, and possibly Yosemite. All of these parks appeared in the high probability of injury quadrants of the risk analysis graphs. Craters of the Moon and Rocky Mountain have just been surveyed this year and no O_3 injury was found. SO_2 injury to vascular plants has not yet been reported from any of the Class I national parks but is being currently investigated. Anecdotal reports of lichen effects from SO_2 have been reported for Olympic, Acadia, Great Smoky Mountains and have been found in Shenandoah, all of which confirms the high risk portion of the analysis. No parks that occurred in the lower right quadrant of the plots, i.e. parks with low probabilities of current vegetation injury, have any current vegetation injury according to our surveys.

In several analyses it appears as if the majority of parks with possible injury occur in the western U.S. This may be due to the fact that 42 out of the 48 Class I national parks occur west of the Mississippi River, i.e. only six occur in the eastern U.S. Thus, any geographic patterns to the park vulnerabilities should not be given serious consideration.

The risk analysis is based on pollutant concentration data drawn from monitoring stations proximate to, but not actually in national parks units. The use of two cutoff distances for SO_2 stations allowed us to compare parks which may experience elevated SO_2 levels at differing points in time. Parks that had high SO_2 data at 100 km stations compared to the 50 km stations may experience elevated SO_2 values farther in the future than parks with higher SO_2 concentrations at the 50 km stations. For example, Saguaro had a very high 100 km SO_2 value which was almost ten times higher than its 50 km value (probably due to more distant copper smelters), while Olympic's 50 km value was about 1.5 times higher than its 100 km value. Thus Olympic is more likely to experience elevated SO_2 than Saguaro in the near future. This type of discussion does not generally apply to O_3 because it is regarded as a regional pollutant.

The analysis described herein includes park vegetation sensitivities only to SO_2 and O_3. Other data are currently being assembled to factor in other pollutants, such as acid rain. If data were available on heavy metal levels in national parks this stress factor could also be incorporated. Adding more pollutants to the study would presumably add to its value for planning purposes, but would not improve the study's accuracy. At this point in time, however, the study has already been used in NPS planning. We hope to perform the analysis repeatedly as new sensitivity information becomes available.

ACKNOWLEDGMENTS

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REFERENCES

Bennett, J. P. A computerized flora of the national parks. George Wright Society Forum 2(2):14-16; 1982.

Esserlieu, M. K.; Olson, R. J. Biological sensitivity of National Park Service Class I areas to atmospheric pollutants. Oak Ridge, TN: Oak Ridge National Laboratory; 1985. 52 p. + appendices. Unpublished report to the National Park Service.

Klopatek, J. M.; J. T. Kitchings; R. J. Olson; K. D. Kumar; & L. K. Mann. A hierarchical system for evaluating regional ecological resources. Biological Conservation 20: 271-290; 1981.

Wetmore, C. M. Lichens of the air quality Class I National Parks. St. Paul, MN: University of Minnesota; 1983. 158 p. Unpublished report to the National Park Service.

ESTABLISHING A BASELINE/PROTOCOLS FOR MEASURING AIR QUALITY EFFECTS IN WILDERNESS

Douglas G. Fox

ABSTRACT: Currently, National Forest managers use a variety of procedures to determine the condition of air quality-related values (AQRV) in Class I areas. AQRV must be related to air pollution and atmospheric deposition through on-site measurements. Uniform measurement procedures acceptable to scientific, regulatory/legal, and management communities for identifying the state of AQRV are needed so that the conditions of, and changes in, AQRV can be compared nationally and withstand litigation which may arise as a result of management decisions about these areas. This paper introduces a preliminary proposed list of such measures.

INTRODUCTION

Air resource management responsibilities of federal land managers call for an inventory of the air quality related values of Class I wilderness (USFS 1982). These values and suggestions of measures of change in them, are listed in table 1.

The air resource responsibility most often resides in the review of formal applications for Prevention of Significant Deterioration (PSD) permits. Such regulatory proceedings demand data that are (1) collected in a uniform and repeatable manner, (2) subjected to strict standards of quality control and quality assurance, and (3) generally acceptable to adversaries (proponents and opponents of the permit).

PSD permit applications begin with a projection, made by an air quality model, of the proposed source's impact on wilderness air quality (Fox and Fairobent 1981). Although air quality modeling is grossly uncertain, the process works because protocols established up front allow agreement between parties (Fox 1984). PSD permitting for Class I wilderness, however, carries the atmospheric modeling process beyond a concentration projection to a projection of effects on air quality related values (AQRV). This, in turn, requires not only a characterization of the current state of selected AQRV, but also of the existing condition and functional relationships of environmental factors that control the deposition and uptake of air pollutants affecting AQRV.

Table 1.--Air Quality-Related Values

1. Flora (plants)
2. Fauna (animals)
3. Soil
4. Water
5. Visibility
6. Cultural-Archeological (i.e., structures, petroglyphs)
7. Geologic (i.e., fossils)
8. Odor

EFFECTS - Flora and Fauna

Changes in:

1. Growth
2. Mortality
3. Reproduction
4. Diversity
5. Visible injury
6. Succession
7. Productivity

EFFECTS - Soil

Changes in:

1. Cation exchange capacity
2. Base saturation
3. pH
4. Structure
5. Metals concentration

EFFECTS - Water

Changes in:

1. pH
2. Total alkalinity
3. Metal concentrations
4. Anion and cation concentrations

EFFECTS - Visibility

Changes in:

1. Contrast
2. Visual range
3. Coloration

EFFECTS - Odor

Changes in:

1. Odor

EFFECTS - Cultural, Archeological, Geologic

Changes in:

1. Decomposition rate

Agreement on modeling techniques is evolving with existing permits. The proposal put forward by Fox and others (1982), that the most sensitive indicator of each AQRV be considered, has been widely adopted (Dames and Moore 1983; TRC 1983). To date, most sensitive indicators have included visibility, the pH of low alkalinity alpine lakes, and lichens. One area of considerable debate and controversy, however, has been trying to agree to the current condition of these indicators in Class I areas. Managers generally have no data to establish a baseline on physical, chemical, and biological parameters assumed to represent the air quality related-values of these areas. Such baseline data are critically needed to support a policy based on preventing adverse change in these parameters.

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In late 1984, a research project was established by the Forest Service at the Rocky Mountain Forest and Range Experiment Station to study the effects of atmospheric deposition on natural alpine systems in the western U.S. Among our highest priority goals is the development of a set of measurements and their associated protocols to establish baseline conditions of AQRV. The process we are using and some of our preliminary thinking about the necessary measurements are described in the remainder of this paper.

HOW SHOULD WE DETERMINE THE NECESSARY PROTOCOLS?

First, as is the custom in Forest Service research, we have drafted a "Problem Analysis" (Fox 1985). This analysis has been reviewed by all the regional air quality specialists in the Forest Service, a number of air specialists, and research scientists in the BLM, NPS, and universities.

The second step, where we currently are, requires expertise to help in drafting the details of the measurement protocols. Dr. Christopher Bernabo, of Science and Policy Associates, Inc., has been contracted, along with a team of 20 prominent scientists, to conduct this work. The third step will involve a wide, but in-depth, review of the draft protocols by the scientific community. Various techniques will be employed to attempt to achieve as much consensus as is possible on the measurements and their protocols.

A final step will be to formally publish the consensus protocols, obtain public input, review that input, and promulgate final protocols.

We intend that this process will involve as wide a distribution of people as possible, not only to reduce controversy but also to popularize the notion of a baseline measurement program for wilderness.

It is also important to note that, in addition to the process described above, we are establishing a long-term research site where the presumed sensitive organisms and systems typical of wilderness can be intensively studied. This site will provide an opportunity to study deposition and its effects in detail, and to develop information to support the measurements and protocols discussed here. The extent to which we will prevail in the establishment of baseline data collection in wilderness depends directly on the extent to which the wilderness community--managers, advocates, and users--accept the protocols we develop.

MEASURES OF AIR QUALITY VALUES

First, we are operating on the assumption that the Clean Air Act and the Wilderness Act both require that wilderness managers "err on the side of conservatism" by protecting the most sensitive component of the system. This follows from a not too controversial hypothesis that by so doing the entire system will be protected. Also implicit is the hypothesis that we can identify the most sensitive component. This may be questionable.

We make a basic assumption that the physical and chemical environment must experience some measurable change prior to any biological change. To determine whether any physical or chemical environment change is likely to have an effect on the biology of wilderness, we have entered into an extensive research program (Fox and others 1985). Conducted primarily on non-wilderness, the information generated must be sufficiently generalizable to be applicable to wilderness areas throughout the western United States. Thus, it is most important to focus on careful measurement of chemical and physical parameters.

In keeping with the worst case philosophy, it may not be necessary to make measurements that can represent the totality of the space or time variation of these parameters in a wilderness, but rather focus on establishing a protocol for measuring maximum values in some sense. This is fortunate, because it is unlikely we could capture the variation of values given the logistical and philosophical constraints of working in wilderness. A focus of our work, then, is to look at chemical and physical measures that are expected to exhibit a measurable change as a result of anthropogenic air pollution sources.

The next logical concerns are with frequency averaging time and duration of measurements. How often do parameters need to be measured to monitor significant changes? Variables that range widely over short time periods, such as meteorological, aerometric, and stream water parameters, can either be sampled for a short time and assumed to represent the time series, or sampled for a long time and averaged. Averaging time is a critical parameter characterizing these types of variables.

Finally, how long do measurements need to be made to ensure capture of the seasonal, natural, and other variations inherent in the particular parameter. To capture the variation of atmospheric parameters, we generally think that a minimum of one year is necessary, and five years is more acceptable. Since we see new record temperatures somewhere in the world every day, it is clear that, from a scientific perspective, continuous monitoring is needed. But, in order to maintain the spirit of the wilderness, measurements within the area must be kept to a minimum and have a finite duration. Thus, we will need to devise protocols that provide for a finite measurement duration. If a measurement needs to be continuous, then perhaps it can be done repeatedly but for limited time, such as one year out of each five.

The protocols suggested include measurements in the atmosphere, in the interface between atmosphere and ground, in the soils, and in the floral and faunal communities thought to be representative of the most sensitive species (where sensitive is defined as most likely to change due to air pollution input).

Another philosophical consideration is that pollutants may be most likely to cause measurable effects at their primary entry points to the ecosystem. A consequence of this hypothesis is that it is not necessary to understand the complex dynamics of natural buffering in ecosystems. Rather, focusing on individual receptors will result in initial indicators of change. Obviously, this hypothesis may be incorrect. There are numerous examples in ecological systems where a small, seemingly insignificant input can lead to a major shift in the system (Peterson and others 1985). Testing this hypothesis for alpine wilderness ecosystems will be a primary focus of our research. For the purpose of establishing baseline measurements, however, we will take it as a working concept. Acceptance of the concept leads to measurements of the foliar surface of vegetation for gases, and of the soil/water system for precipitation-transported chemicals. In all of the measures we suggest, we attempt to maintain a respect for the basic values of wilderness that we are seeking to protect.

In the following, we list some suggestions of measures.

Measurements in the Atmosphere

Visibility.--Visibility may prove to be the most sensitive indicator of all AQRV because the pollution need never touch down on the area. Two instruments are available for the measurement: a teleradiometer, which measures the contrast reduction between a distant target and sky caused by intervening air pollution (absorbers and scatterers of light) and, more simply, an automated camera system. Although both instruments can be operated with only minor maintenance, (film changes, etc., required on a weekly or semi-weekly basis), they represent a level of technology incommensurate with wilderness values. To accommodate the visitation frequency required to preserve wilderness values, we propose locating visibility instruments nearby at similar elevations, observing paths similar to those in the wilderness wherever possible.

Obviously, not all wilderness will require visibility monitoring. Those in the southwest, where visibility values are of greatest significance, those near imminent development, and locations where land management requires significant use of fire (Northwest), are the most likely sites for visibility measurements.

Permit meteorology.--Air resource managers need meteorological data for two purposes: for the PSD permit, and to quantify the atmospheric environment associated with and as a measure of AQRV. Permit meteorology is oriented around the source. Data are collected to help estimate the atmospheric transport and diffusion properties between the source and the wilderness. These measurements are made in the atmosphere at least 10 m or higher above the surface. They generally do not need to be made in the wilderness itself.

Measurements in the Atmosphere/Surface Interface

System measurement.--The interface involves a region of the atmosphere that contains solid surfaces. Atmospheric variables change dramatically in both space and time in this region. Because it is difficult to characterize variables with a single measurement, some sort of modeling must be introduced to extend the representativeness of a measurement.

AQRV meteorology.--Although land management agencies conduct meteorological and climatological measurements on a routine basis, few are made in areas representative of the AQRV environment. Thus, meteorological measurements are needed to characterize microclimate in the vicinity of the specific AQRV in question. This is a ground-based measurement made at the surface/atmosphere interface. To characterize this environment, it is necessary to measure wind speed and direction, temperature (air and ground), humidity, and precipitation. Cloud cover and average radiation would also be useful.

Unfortunately, meteorological measurements require high technology instrumentation. It is well within the state of the science to operate solar-powered, remote instruments that record information on site, or telemeter data via the GEOS satellite. Because of clear incompatibilities with the wilderness philosophy, it is recommended that these measurements only be taken at the boundaries of the wilderness, or nearby on areas that are representative of the wilderness. Models can be useful in extrapolating to the interior of the wilderness.

Chemical deposition measurements.--Because the atmosphere/surface interface is a primary entry point for pollutants, a number of suggested measures are focused here. Measurement of the chemical content of deposited rain and snow is necessary. It would also be desirable to measure dry deposition of pollution. Dry deposition is a term that describes the amount of chemical removed from the atmosphere when it is not precipitating.

Since chemicals are removed by being adsorbed on or into a surface material (vegetation, soil, etc.), removal is not easily measured. As a surrogate, we suggest measuring the concentrations of gases and aerosol particles. The latter can be measured with solar-powered, low-volume samplers, which are, at best, marginally compatible with wilderness. The former cannot, at present, be measured with the required accuracy in a manner compatible with wilderness. There is, however, reason for some hope in the current generation of research-grade sensors (Hicks and others 1985). These instruments consist of a small group of filters that trap and adsorb various chemicals. These measurements, of course, can only be made at the wilderness boundary. Wet deposition is more easily measured, but also

not without problems. Wet/dry bucket collectors are used nationwide by the National Atmospheric Deposition Program (NADP). These collectors consist of two buckets. A roof covers the wet bucket when there is no precipitation. A sensor activates a mechanism to move the roof off the wet bucket and onto the dry bucket when precipitation occurs. They are excellent for collecting rainfall, but, because the sensor that moves the roof is not always activated, they are not perfect for collecting snow, and almost useless in an alpine environment. The wet/dry collectors are mechanical equipment and, as such, must be located at the boundary of the wilderness.

An alternative to wet/dry collectors, one which does not require any mechanized equipment, is the collection of bulk precipitation in plastic bags, suspended in a deep barrel (or upturned culvert). The bag can be collected whenever convenient. The difference between bulk and wet only precipitation chemistry is not well understood. Superficially, bulk precipitation should exhibit a higher concentration because of its exposure to dry deposition, that is, absorbtion of gases in the standing water. In fact, what data exist seem to show just the opposite (Reddy and Claassen 1985; NADP 1985). Although considerable research is needed to establish the significance of bulk precipitation measurements, they are a reasonable way to make measurements in the wilderness.

A third alternative is simply to collect snow samples and analyze them for chemical concentration. While this does not provide any information about rain, it is the least mechanized and most consistent with the wilderness philosophy. Unfortunately, snow that accumulates in a snow pack changes its basic structure--it metamorphoses. This metamorphosis leads to a redistribution of chemicals collected in the snow (Hobbs 1974; Sommerfeld 1983). Since the implications of this redistribution are not well understood as yet, data on the chemistry of snow cores is not currently useful.

Whatever collection method is used, a uniform protocol is needed for sample handling and for chemical analysis. To minimize potential for controversy, this handling and analysis must be accompanied with appropriate quality assurance and quality control. Chemical analysis is discussed further in the following sections.

Measurements in Soil/Water

System measurements.--As has been shown most recently by the EPRI Integrated Lake-Watershed Acidification Study (EPRI 1984), the sensitivity of a watershed to changes in atmospheric deposition depends upon an integration of many factors, including its soil, hydrologic, and geologic characteristics. In general, we can call these control factors. We need to measure them to determine the amount of alkalinity (buffering the acidic input) supplied from the watershed to the water flowing through it, and to the plants and animals living on and in it.

The control factors are of three broad categories: (a) energy flux to the site, (b) parent material chemistry, and (c) hydrology and water chemistry. The first describes the potential physical and biological buffering capacity of the site, the second describes the geochemical buffering potential, and the third describes the actual condition.

Factors involved in determining energy flux include meteorological parameters discussed above, terrain considerations that can be easily determined from maps (slope, aspect, and slope length), and integrated effects that need to be monitored in the wilderness (growing season, soil moisture availability, soil characteristics, etc.). Together these variables determine the potential of a site for biological productivity. It may be possible to identify specific sites within the wilderness where some of these variables can be measured routinely. Modeling could be used to extend meteorological parameters from their offsite measurement point to the site.

Parent material chemistry can be determined from the basic geology of the site. Many wildernesses have had fairly extensive geological survey work. It may be necessary to take detailed soil samples at strategic locations determined from the surveys. Soil chemistry from these samples can be incorporated with mineralogy of bedrock geology to provide input to models that predict the alkalinity of soil water.

In some cases, the hydrology of the site may be determined by soil physical characteristics, depth, texture, moisture regime, and degree of channelization. Measurement of soil water chemistry can provide an indication of the actual buffering capacity. This information, in comparison with the theoretical alkalinity predicted by mineralogy models, can indicate the potential for deposition effects.

Water chemistry measurements.--The chemical condition of water in the wilderness will be used as a primary indicator of the health of the system. A systematic method to measure this water is needed. Water can be in lakes, streams, bogs, and in the soil. Lakes are probably of greatest interest because they integrate the effects of the terrestrial ecosystem surrounding them. A protocol that ensures the entire lake is sampled, particularly during periods when it might be stratified, is needed. Inlets and outlets, to the extent they are identifiable, might be the optimal sampling locations. Soil water can be sampled using small subsurface lysimeters. These are installed and sampled by applying a slight tension on the soil water column. Although they are, in fact, structures, they can be deployed unobtrusively. They may not represent too much of a conflict with wilderness values. An alternative is to simply locate seepage areas where the subsurface

water can be sampled, at least when it is running. Also, a protocol is needed to define the frequency of sampling, as well as some statistical design to identify the magnitude of spatial sampling needed. In designing these, we will be guided by the concern with worst-case or most-sensitive components. Much work on the chemical methodologies has been done by the EPA National Surface Water Survey (Hillman and others 1984).

Chemical analyses can be conducted on site (pH, conductivity, temperature), or in a laboratory for further measurement. It is suggested that pH, alkalinity, conductivity, and the major cations (Ca, Mg, Na, K, NH_4), and anions (NO_3, SO_4, Cl) be analyzed. Since much of this water will be very low in ionic strength, it is appropriate to use atomic absorption and ion chromatography, and to maintain high standards of quality control. It is anticipated that commercial analytic laboratories will be used, at least until the program of measurement is large enough to support a central analytical laboratory with adequate quality control.

Soil measurement.--Again, a protocol for soil sampling that can actually be done in wilderness is needed. Statistical design must be recognized because of the extreme variation in soil characterization from site to site (Mason 1983). The guiding principle will remain identification of a soil that is most sensitive to atmospheric deposition. The vertical distribution of the soil should also be recognized.

Geologic maps are generally available for the wilderness. Soil maps may also be available. At sites selected for their sensitivity, soil pits can be dug unobtrusively where soil physical and morphological characteristics (type, depth, color, structure, texture, density, mineral soil texture, water content, etc.) can be determined. Additionally, chemical analysis of pH, inorganic carbon, total organic carbon, nitrogen, sulfur, cation exchange capacity, exchangeable bases and acidity, extractable iron and aluminum, extractable sulfate, and mineralogy can be done at a laboratory. These parameters would be used more as a survey to locate sensitive soils. It would not be necessary to sample and analyze these values on a regular basis. The water measurements should be sufficient to accomplish routine monitoring.

Measurements of Flora

System measurements.--Considerable effort has been expended recently to classify land as to its potential biological productivity (Mauk and Henderson 1984; Brown 1983; Hoffman and Alexander 1980). These techniques are suggested for mapping the wilderness area, if this has not already been done.

Ecosystems can be described by measures of their composition, structure, and function (process). In particular, it is logical to focus attention on dominant components of each ecosystem. Study will be directed toward understanding the environmental and competitive factors accounting for the health and vigor of these dominant components. In the absence of such information, we suggest a standard level of monitoring designed to identify, in a rudimentary fashion, the health of the ecosystem and perhaps some key transfers among elements of the system. Since our objective remains to measure any change, we must direct attention toward the most sensitive species, so-called indicator species. Although subject to considerably more study, at this point the following are suggested.

a. Measures of Composition and Structure. Survey living vascular plants above some minimal size or distribution class. Identify any known species sensitive to air pollution. Survey (1) herbivory, (2) pathology, and (3) vertebrate populations associated with the area. A cryptogam survey should be focused toward sensitive and historically significant species (see below).

b. Measures of Function/Process. Litterfall represents an initial measure of productivity that might prove more important than more conventional (for the Forest Service) measures such as increment growth or net production. Other measures that have been proposed (Wiersma 1985; Herrmann 1985) include litter decay rates, leaf/needle population retention, other phenology measures, nutrient flux into the soil (using ion exchange resins adapted to field use), and chemical analysis on various components of the living and dead biomass.

Measurement of most-sensitive species.--Lichens have historically been used as indicators of air pollution (Jerry 1973; Rhoades 1981) because of the relative simplicity of their physical and biological structure. Considerable information exists to indicate the response of lichens, especially to SO_2, F, heavy metals, and photochemical oxidants (Hale 1983). Lichens are long-lived, and they accumulate pollutants throughout the year. They are able to assimilate materials that would be toxic to other plants and bind them in cell walls. Thus, chemical analysis of lichen tissue can provide a historical record of pollution levels. By establishing lichen study plots, it may also be possible to identify pollution trends. Hale (1983) has suggested establishing plots of the lichen *Xanthroparmelia cumberlandia*. This lichen is easily identified, ubiquitous, and has been correlated with air pollution in many studies.

Hutchison-Benson and others (1985) measured the amount of ^{137}Cs present in a number of lichen species; a bryophyte (*Polytrichium juniperinum* (Hedw.), a common arctic moss);

and three vascular, cushion-like species (Dryas integrifolia (M.) Vahl., Saxifraga oppositifolia (L.), and Silene acaulis (All.) D.C.). This cesium came exclusively from atmospheric deposition. Compared with dynamic humid temperate ecosystems, arctic and alpine ecosystems remove these contaminants to abiotic sites very slowly. Thus, species such as these will be likely indicators for atmospheric changes.

Bryophytes located at the outflow regions of alpine lakes may prove most useful for monitoring because they filter essentially all the water passing through the lakes. Although it will require a significant amount of study, it may be possible to develop any of the above-mentioned species so that they can actually be placed at study sites in the wilderness, and left to accumulate future deposition. Obviously a considerable amount of research would be necessary to ensure and appropriately judge the viability of such indicators.

Of equal concern with the terrestrial biota in wilderness is the health of the aquatic ecosystem. Phytoplankton appear to be key indicators. Various aspects of the phytoplankton population will be sampled. Both population and species diversity can be used as measures of the condition of the ecosystem. Such measures are not conclusive in themselves, however, because of the vast complexity of these ecosystems. Considerably more research will be necessary before such indicators will have much utility in wilderness protection.

Measurements of Fauna

Vertebrates.--Although not likely to indicate any changes as a result of air pollution, a survey of the population is needed to provide baseline information. Of particular interest are fish in wilderness lakes and streams. Fish will be surveyed. While many of these fish have been introduced, a primary concern remains that their habitat not change significantly, to the point of not supporting reproduction, for example.

Zooplankton.--Since aquatic systems appear to be the most sensitive to effects on fauna, zooplankton and macroinvertebrates in this environment can be sampled to serve as early warning indicators of stress. There are accepted procedures and indices developed to indicate potential biological productivity by sampling lake microorganisms. Mangum (1984) presents a clear picture of the options.

SUMMARY AND DISCUSSION

This paper outlines a set of measurements in the atmosphere, in the interface between the atmosphere and the surface, in the soil/water system, and of selected species of flora and fauna. The list is intended to be comprehensive but realistic. It recognizes the challenges of working in wilderness, and attempts to accommodate wilderness values rather than compromise them. These measurements are thought to represent a useful yet conservative set. We have attempted to define a highly sensitive set of parameters that will measure initial changes to individual organisms as well as to the ecosystem. Considerable study will be needed to relate these parameters to the general health and functioning of the ecosystem. Similarly, we are not implying by suggesting these measures any level of acceptability or adversity associated with them. Such value judgments are the responsibility of the manager acting in concert with the public.

In addition to being necessary tools for the manager to redeem air resource responsibilities in Class I wilderness, these measures may prove useful as a baseline program for all wilderness. As increasing pressures are applied to wilderness from off-site pollution sources as well as from on-site usage, better information about the baseline condition of wilderness values will result in better decisions to protect the wilderness. It is our hope that wilderness value measures will find their way into most wilderness plans.

REFERENCES

Brown, D. E., ed. Biotic communities of the American Southwest United States and Mexico. Desert Plants. 4:3-341; 1983.

Dames and Moore, Inc. PSD Permit Application, Exxon Company, USA LaBarge Project. Submitted to Wyoming Dep. of Environ. Quality, Job No. 08837-165-14. Dames and Moore, Golden, CO. 1983. 35 p.

EPRI. The integrated lake-watershed acidification study. EPRI-EA 3221, Palo Alto, CA. 1984.

Fox, D. G.; Fairobent, J. R. NCAQ panel examines uses and limitations of air quality models. Bulletin American Meteorological Society. 62: 218-221; 1981.

Fox, D. G.; Murphy, D. J.; Haddow, D. tech. coords. Air quality oil shale and wilderness. General Technical Report RM-91. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1982. 31 p.

Fox, D. G. Uncertainty in air quality modeling. Bulletin American Meteorological Society 65:27-36; 1984.

Fox, D. G. Problem Analysis: Protocols for establishing chemical and physical baselines for natural ecosystems have not been established. 19 p. Unpublished manuscript on file at: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Fox, D. G.; Schoettle, A.; Yancik, R. Effects of atmospheric deposition on alpine and subalpine ecology: A proposed framework for western research. Unpublished manuscript on file: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. 1985.

Hale, M. E. Lichens as bioindicators and monitors of air pollution. Unpublished paper submitted to U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Lakewood, CO. Research Contract R2-81-SP35; 1983. 30 p.

Herrmann, R. The effects of atmospheric deposition-long-term ecological measurements in representative National Parks. Unpublished draft MS, available from National Park Service; Colorado State University, Fort Collins; 1985.

Hicks, B. B.; Hosker, R. P. Jr.; Womack, J. D. A simple meteorological and chemical system for inferring dry deposition. Atmospheric Turbulence and Diffusion Division, National Oceanic and Atmospheric Administration, Air Resources Laboratory, P.O. Box E, Oak Ridge, TN. Draft rep. Sep. 30, 1985; 1985.

Hillman, D. C.; Morris, F. A.; Potter, J. F. and S. J. Simon. Methods manual for the national surface water project - Phase 1. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.; 1984. 232 p.

Hobbs, P. V. Ice physics. Oxford University Press, London; 1974. 837 p.

Hoffman, G. R.; Alexander, Robert R. Forest vegetation of the Routt National Forest in northwestern Colorado: A habitat type classification. Res. Pap. RM-21. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1980. 41 p.

Hutchison-Benson, E., Svoboda, J.; Taylor, H. W. The latitudinal inventory of ^{137}Cs in vegetation and topsoil in northern Canada, 1980. Canadian Journal of Botany 63:784-791; 1985.

Jerry, B. W., et al. Air pollution and lichens. University of Toronto Press, Canada; 1973. 273 p.

Mangum, F. Aquatic biology of selected lake ecosystems in the Wind River Mountains. In: Workshop Proceedings on Air Quality and Acid Deposition Potential in the Bridger and Fitzpatrick Wilderness. U.S. Department of Agriculture, Forest Service, Intermountain Region. Ogden, UT. 1984: 127 p.

Mason, B. J. Preparation of soil sampling protocol: Techniques and strategies. EPA Report 600/4-83-020. U.S. Environmental Protection Agency, Environmental Monitoring Sytems Laboratory, Las Vegas, NV. 102 p.

Mauk, R. L.; Henderson, J. A. Coniferous forest habitat types of Northern Utah. General Technical Report INT-170. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984. 89 p.

National Atmospheric Deposition Program. NADP/NTN Rep.: Precipitation chemistry, Fourth Quarter, 1983. Fort Collins, CO : Colorado State University, Natural Resources Ecology Laboratory; 1983. 280 p.

Peterson, B. J.; Hobbie, J. E.; Hershey, A. E. et al. Transformation of a tundra river from heterotrophy to autotrophy by addition of phosphorus. Science 229: 1383-1386.

Reddy, M. M.; Claassen, H. C. Estimates of average major ion concentration in bulk precipitation at two high altitude sites near the Continental Divide in southwestern Colorado. Atmospheric Environment 19:1199-1203; 1985.

Rhoades, F. 1981. Bryologist 84(1): 39-47.

Sommerfeld, R. A. 1983. A branch grain theory of temperature gradient metamorphism in snow. Journal of Geophysical Research 88: 1484-1494.

TRC, Inc. PSD permit application, Wyoming Air Quality Control Division. 1983.

U.S. Forest Service. Handbook, 2120 Section. Washington, D.C. 1982.

Wiersma, G. B. Recommended integrated monitoring system for pollutants in U.S. National Parks designated as biosphere reserves. Idaho Falls, ID; Informal Report. E66-PBS-6721. Idaho Natural Engineering Laboratory, E.G. and G. Idaho, Inc.; 1985. 82 p.

Section 3. Wilderness Soil and Vegetation Research

IMPACT ECOLOGY KNOWLEDGE IS BASIC

Fred R. Kuss
Session Coordinator

What is more basic to ecological processes than plant and soil responses to environmental change? What is more basic to environmental change in Wildernesses than human activity? And what is more basic to human activity in such settings than recreation and its impact on plants and soils?

Nevertheless, we are hard pressed to pursue the study of these relationships due to a number of factors. Perhaps the most salient is that few of us can afford the luxury of devoting a professional lifetime to recreation-related impact ecology research due to limited career opportunities and funding, as pointed out by Dave Cole in his state-of-the-art paper. As we review the field, we are indebted to the collective efforts of those who have ventured into the field even for only a brief period of time, since much of this work has provided building blocks to our knowledge base. Yet what is more basic to gaining knowledge of the interdependencies that underscore the principles of ecology than the field of impact ecology?

From 1964 until recently, the primary concern of Wilderness supporters has been allocation. Although allocation studies are still in progress, the intensity of public interest is shifting to the question of how best to manage these systems to conform with the preservation philosophy. A walk through the conservation-related history of the 20th century finds the Forest Service now sharing the preservation philosophy with the National Park Service in terms of Wilderness management. This becomes an opportunity to initiate stronger communication and cooperation between the two major agencies most involved with Wilderness in terms of ecological research as well as with international interests. However, a factor limiting this proposition is that we still suffer the problem of recreation-oriented research being subordinated to the interests of other, more mature, disciplines and there is little communication between agency researchers.

The issues of conflict management between preservation and use; the limits of acceptable change; protecting rare, unique, and fragile habitats; the dimension of uncommon, rare, and endangered plant management; future implications of the exotic plant problem; and the resiliency or irreversible degradation of impacted areas are common to all Wildernesses as are the linkages and relationships that influence ecosystem dynamics irrespective of management agency. Cooperative research and information exchange such as we see at this conference offer hope that we may accelerate our understanding of impact ecology and will not be called upon in the future to answer the question, "How come nothing's like it was until it's gone?"

Like all programs of a qualitative nature, it is necessary for us to establish what was there, what is there, and most important, what will be there in the face of change. While change is also part of the natural process and the timelessness of nature, the comparatively recent introduction of human activities (external and internal) to these pristine areas potentially creates selection pressures to which most native flora have not adapted. These concerns call for greater allocation of resources in support of ecological research if there is to be a balance between the biocentric and anthropocentric philosophies of Wilderness management and a reasonable continuity to our research.

There is a great diversity of problems and issues to be addressed in Wilderness-oriented plant and soils research as will be evident from the papers that follow. These range from detailed descriptions and interpretations of ecological surveys to many site- or area-specific studies that raise questions about the future management policies of Wilderness areas. It has been said that the scale of observation creates phenomena. We see recreation-oriented research proceeding with the necessary descriptive and survey phases of research to a scale of observation that seeks to explain why various forms of impact occur and how such events can be modified by management policy and direction.

In an exercise such as this, my position is that it is not necessary to summarize each paper. I leave that to the reader's curiosity and interest. Rather, my comments are directed at the quality of the papers and the contributions to plant and soils research they represent. Having spent the last 3 years reviewing the literature in this area, I feel qualified to do so.

Each of these papers should serve as a standard for future research and as a means to influence management actions for protecting wilderness values. As I view these papers, they impart a pragmatic view toward management operations, but defend the preservation philosophy within the limits of practicality. The question of rare plant protection and management is raised by two papers (Cooper; Hamilton and Lassoie); the

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challenge of how to deal with the growing problem of exotic plant species and their effects on native flora is brought to focus by Marion, Cole, and Bratton. Rare indeed are longitudinal studies of campsite or trail degradation addressed in three separate papers (Bayfield; Marion and Cole; Thornburgh). A study that reports changes in soil chemistry which accompany gradients of campsite use is also rare in the literature (Stohlgren); the exhaustive work of Burde and Renfro provides a better understanding of the variables most important to trail wear, management, and rehabilitation as does, in part, the work of Kuss. Basic principles of carrying capacity are discussed by Kuss, Graefe, and Loomis and finally, but by no means the least, the paper by Shelby and Harris discusses the standards of acceptable change wilderness users place on the extent and degree of campsite degradation and who these standards may vary according to location and experience sought. Continued information such as this will serve to better define the activity-experience-setting relationships to satisfaction and the social perspective needed to establish standards for application of the Limits of Acceptable Change or Visitor Impact Management processes.

Problems of research design were mentioned by Stohlgren, and I should like to take the discussion a bit further. Because there are so few of us engaged in this kind of research, I might suggest that we collectively consider the possibility of standardizing our research designs in certain areas of inquiry. Certainly, studies designed to determine habitat, community, and species resistance, resiliency, and the physical, chemical, and biological changes that accompany campsite use should lend themselves to this concept. It is not the intent of these comments to suggest doing away with the creativity and innovation that draws many of us to research. However, with standardized designs and measurements of the same parameters, a data bank could be generated by the few of us engaged in wilderness research which would allow for comparisons of diverse systems and their responses to different activities and use levels ranging from the Arregetch Peaks area of the Brooks Range to the Great Smoky Mountains as covered by papers of this session.

This idea is not new since through the efforts of 26 different experiment stations cooperating in this manner, the Universal Soil Loss Equation was developed which has a high reliability for predicting soil loss as influenced by variables such as precipitation, soil texture and structure, percent and type of ground cover, height and density of overstory, slope, and management practices. Nor is the concept new to the field of impact ecology since standardization for comparing different systems has been set in motion by Liddle (1975), Weaver and others (1979), and Cole (1984). By agreeing to appropriate field designs, it is not beyond possibility that equations or models could be developed that would predict how a given site, habitat, area, or ecological landtype might respond to different use levels and activities. This is a call to consider this proposition.

THE ARRIGETCH PEAKS REGION OF THE CENTRAL BROOKS RANGE, ALASKA: ECOSYSTEMS AND HUMAN USE

David J. Cooper

ABSTRACT: The Arrigetch Peaks region of Alaska's central Brooks Range combines tremendous visitor appeal for recreation purposes and ecological diversity. Critical issues for wilderness managers include dynamics of palsas and treeline, disturbance to Cladonia lichen dominated stands and their regeneration rates, rare and important plant species and associations, and soil erosion rates from heavy use sites.

INTRODUCTION

The Arrigetch Peaks region of Alaska's central Brooks Range (67.6 degrees N latitude, 154 degrees W longitude) combines tremendous ecological diversity and wilderness visitor appeal. The Arrigetch Peaks were carved from a granitic pluton by Pleistocene glaciers into sheer and nearly vertical hornes and aretes with up to 1000 m of vertical relief. The peaks are truly a unique and fascinating feature in Arctic Alaska because there is so little massive granitic parent rock in the Brooks Range. They are proposed as an ecological natural landmark (Bliss and Gustafson 1981). The granites and gneisses of the Arrigetch Pluton contact limestone and marble of the Skajit Formation in the Arrigetch valley and it is one of the few places in North America where these two parent materials occur together. The limestone forms steep to gentle slopes, cliffs and talus. The flora, vegetation, and ecological processes of the two substrate types are distinct and different.

The research reported here stems from a study of the arctic-alpine tundra flora, vegetation and soils of the Arrigetch Creek valley and region from 1976 to 1981 (Cooper 1983). This was the first detailed study of arctic-alpine tundra ecology in the central Brooks Range and the data provide an information link between Alaskan mountain vegetation and ecology with that of Scandinavia, Canada, Greenland, Siberia, and Europe, along with the lower 48 United States. The Brooks Range is magnificent country, and for the most part pristine. Not one non-native plant species occurs in the Arrigetch Creek valley. It provides an unparalleled opportunity to study truly natural ecosystems. Many features of the region's ecology are essential for the wilderness manager to incorporate into land use plans. This information can be used to maintain biological diversity and ecological processes of even heavy use areas. As visitor use increases and intensifies ecological information derived from pre-impact studies will be precious. The purpose of this paper is to address some of the important ecological processes and the resulting patterns of biological and ecological diversity found in the Arrigetch Creek valley and to point out their significance for management.

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HISTORY OF THE REGION

The first group of Caucasians, a geological survey party led by Phillip Smith, to visit and publish a report with photographs on the upper Alatna River region of the Brooks Range occurred in 1911 (Smith 1913). They visited what later became known as the Arrigetch Creek valley, yet their only mention of the area was that the high peaks made passage impossible.

The name Arrigetch, an Eskimo term meaning "fingers of the hand extended", was given to the peaks by Bob Marshall (Marshall 1970) in the 1930's. Marshall was a forester and explorer who traveled throughout the central Brooks Range in the late 1920's and 1930's and developed several theories on polar treeline ecology. Just after World War II, Bud and Connie Helmericks took up residence in the Alatna River-Walker Lake region of the Brooks Range and the many cabins they built are still the primary human developments in the area.

The Arrigetch Peaks region has become a popular summer visitor spot since the late 1960's. Fifty to seventy-five people hike or ski into the valley each year with the average stay being 1-2 weeks. Many visitors feel that the Brooks Range is a true wilderness or ultimate wilderness. Ironically northern Alaska was probably the first region in North America inhabited by man, and a more or less continuous occupation by various Eskimo and Athabascan Indian people has occurred for many thousands of years.

METHODS

The vegetation of the Arrigetch Creek valley was sampled and classified using Braun-Blanquet methods which were developed in the European Alps for the study of alpine tundra vegetation (Braun-

Blanquet 1932). This method uses floristic-sociological criteria as the sole basis for hierarchical classification (Westhoff and Maarel 1978). Data from four hundred and seventy six stands of vegetation were used in the final analysis. The soil in almost every stand was examined and its characteristics described including depth and characteristics of horizons and pH in the rhizosphere. Permanent strip transects were established in 1978 around the main camping area in the Arrigetch Creek valley to initiate a quantitative data base for monitoring the effects of human trampling. The location of rare plant species was mapped and detailed collections of vascular plants, lichens and mosses were made. A total of 579 plant taxa occur above treeline in the Arrigetch valley. Plant nomenclature follows Hulten (1968), Packer (1972) and Argus (1973) for vascular plants, Thomson (1979) for lichens, and Crum, and others (1972) for mosses.

RESULTS

The vegetation of the Arrigetch Creek valley was classified into 49 associations. The classification provides a framework upon which to organize local and regional biological information, allows easy comparison with other Holarctic regions, facilitates study of relationships between animal species and vegetation, and relationships between associations. Some of the associations are rare and very localized, characterized by species with narrow niches. Other associations are widespread and abundant, and nearly identical in floristic composition and ecology to associations described from other arctic and alpine regions of the Holarctic. A few associations cover large portions of the study area. While some of the species and vegetation types are of great interest, ecological processes which control the distribution of species and ecosystems are most critical to understand, but much more difficult to integrate into management plans.

Ecosystem Dynamics

Slope processes.--On steep slopes in the Brooks Range, mass-wasting processes such as gelifluction, mud-flows, and debris-flows are ubiquitous. These processes control the distribution of stable and unstable sites and thus the maturity or youthfulness of soil. The composition and distribution of present day vegetation on the limestone uplands is controlled by these factors. The most abundant species are Dryas octopetala ssp. octopetala, Salix reticulata, Carex scirpoidea, and Cassiope tetragona. These species have attained dominance because they are genetically adapted for a myriad of moisture and soil conditions. The openness of plant communities on limestone allows many species which are poor competitiors to find niches.

Habitats on stable soils.--The Pleistocene climate of Beringia (the unglaciated refugium of interior Alaska, the Bering Land Bridge, and eastern Siberia) is hypothesized as being considerably colder, drier and windier than the present climate (Hopkins 1972, 1974; Sergin and Shcheglova 1976; Hopkins and others 1982). This drier climate and shorter warm season may have limited many mass-wasting processes such as gelifluction (downslope movement occurring in soil with permafrost) resulting in more extensive stable slopes along with loose and aeolian soils. Greater slope stability would dramatically change the ecological situation on slopes, allowing species now restricted to tiny stable islands to expand their ranges. Because stable habitats are rare in the present climatic regime these sites provide critical habitat for many plant species which cannot compete with the widespread Dryas octopetala ssp. octopetala and heaths.

Rare associations occurring on stable sites include the following: (1) Elk Sedge (Kobresia myosuroides) dominated stands which occur on the stable face of steep limestone cliffs and outcrops where winter snow is shed very early; (2) fellfields on limestone dominated by dwarf willow (Salix rotundifolia ssp. dodgeana) is the primary habitat occupied by several Alaska-Yukon endemic species including Erigeron hyperboreus, Senecio ogotorukensis, Saxifraga eschscholtzii, and Oxytropis nigrescens ssp. bryophila; (3) an association characterized and dominated by Carex nardina, which occupies the tops of stable limestone hills and outcrops.

"Arctic-Steppe" vegetation.--On coarse scree at the base of the most xeric and warmest limestone bluffs and cliffs on coarse scree vegetation dominated by sagebrush (Artemisia alaskana), grasses (Calamagrostis purpurascens, Poa glauca), forbs (Saxifraga tricuspidata, S. reflexa, Selaginella sibirica), lichens (Diploschistes scruposes, Acorospora schleicheri) and mosses (Hypnum vaucheri) which are characteristic of arid grasslands may be found. These habitats are heavily utilized and manured by Dall sheep.

Many researchers believe that an "arctic-steppe" biome characterized Beringia during full-glacial intervals which were the coldest and most arid periods of the Pleistocene (Matthews 1976; Young 1976a,b; Murray and others 1982; Yurtsev 1984a,b). A rich mammalian megafauna is known to have occupied Beringia during the Pleistocene (Guthrie 1972) which may have been supported by the "arctic-steppe" ecosystems. Vegetation which hypothetically is relictual "arctic-steppe" has been fully described on the Siberian side of the Bering Sea, but relicts are not well-known in Alaska. The stands to be found in the Brooks Range and those found elsewhere in central Alaska thus may provide a valuable clue as to the nature of this Pleistocene biome which is for the most part extinct.

Cladonia lichen mat characteristics and dynamics.--Granitic talus and non-ice-cored glacial moraines form generally stable habitats. The primary colonizers of these habitats are foliose and crustose lichens which form species rich communities. In the most stable sites sediments from the eroding rocks have accumulated in the cracks between rocks and very acidic

podsol-like soils have developed. These soils are colonized by fruticose lichens, especially the reindeer lichens (Cladonia stellaris, C. arbuscula, and C. rangiferina), along with a few mosses, especially Rhacomitrium lanuginosum. These species combine to form mats which spread and form a continuous veneer up to 20 cm in thickness over the bouldery substrate. Primary succession leading to development of lichen mats takes thousands of years and evidence of this succession is obvious throughout the Arrigetch Peaks region. The lichen mats are floristically rich in lichen species and are characterized by a number of vascular plant species as well, especially Cassiope tetragona, Ledum palustre ssp. decumbens, Vaccinium uliginosum, V. vitis-idaea, Festuca altaica, and the rare Gentiana glauca, and Campanula lasiocarpa.

The Arctic has been termed "fragile" for several reasons. One is that lichens are brittle when dry and easily crumbled to powder. Also because they are not rooted to the ground the mats are easily eroded once disturbed. An individual lichen plant may be many hundreds of years old, and colonization rates are very slow. Other reasons include the low annual productivity which makes recovery very slow, and permafrost which can be easily disturbed.

Growth rates of reindeer lichens have been established for several areas of Alaska, Canada and U.S.S.R. and range from 2.7 to 5.8 mm per year (Pegau 1968). Where the podetia (the upright, hollow and branching portion) of lichens are disturbed as occurs with caribou grazing, recovery rates of 35 to 75 years are to be expected. Four visitors camped in a reindeer lichen dominated stand in the Arrigetch area for 10 days in 1979 created a bare spot of approximately 12 square meters. The disturbance eroded parts of the stand to bare soil. Recovery time may be considerably greater than 75 years because lichen growth rates in the high Brooks Range are probably not as fast as those cited.

Cladonia lichen mats are abundant in boreal and arctic regions with continental climate throughout the world and have a remarkably consistent floristic composition. While the lichen mats cannot be propagated as yet, ecosystem recovery may be assisted by lichen mat transplants from other less critical regions.

Marsh processes involving palsas.--A palsa complex occurs in one tributary valley of Arrigetch Creek. Palsas are ice cored mounds up to 2-3 meters in height which occur in marshes. In the Arrigetch valley palsas can grow and expand rather rapidly set off by climatic cooling such as occurred between 400-100 years ago (Hamilton and others 1982) and during the 1950´s-1960´s (Perry 1984). Palsas persist for one to several centuries.

The growth of palsas raises a patch of marsh vegetation above the marsh facilitating drainage. Species comprising the marsh vegetation die and the surface is colonizded by tall willows, characteristic of mesic uplands. Palsas eventually melt out during processes driven by gelifluction on palsa sides and thermokarst (melting of permanently frozen ground, resulting in a karst-like topography) forming a pond (Cooper 1985c). Ponds are filled in by silt and colonized by bryophytes and sedges, and eventually vegetation similar to undisturbed marsh is restored. The rate of palsa melting is apparently much more rapid during warm climatic periods such as the warm period from the 1880´s to late 1950´s (Hamilton 1965a,b; Garfinkel and Brubaker 1981) during which most Arrigetch valley palsas apparently melted. As of 1981, 17 palsas are in some stage of cyclical succession, and their dynamics are critical for understanding the ecology of these marshes. Palsas are closely in balance with current climate and are sensitive indicators of climatic change or other disturbance which would alter their energy budget.

Treeline dynamics.--I have found white spruce (Picea glauca) trees in the Arrigetch Creek valley at elevations up to 1465 m (Cooper 1985b) which is more than 700 m above the regional treeline that occurs around 760 m elevation. These trees occur on south-facing limestone slopes and appear to be in highest elevation found so far north of the Arctic Circle in North America and probably are among the highest trees in Alaska. It is suprising to find the highest trees so close to the polar treeline, however the limestone parent material, continental climate with fairly warm and sunny summers and deep and continuous winter snowcover may provide perfect conditions for the trees. It is unclear whether or not these trees represent a general advance of treeline in response to the 20th Century warming described earlier. Whatever the reason is, treeline is extremely responsive to climate changes.

Rare Plant Species

Vascular plants on limestone.--Vegetation on limestone slopes is almost always very open exposing much bare soil. This allows species with poor competitive ability to find niches. Many very rare vascular plant species occur in northern Alaska only on limestone. The Yellow Lady Slipper (Cypripedium calceolus ssp. parviflorus) has its main distribution in Alaska in the southeastern panhandle and near the border with Yukon Territory. A few small populations of this species occur in the southern Brooks Range, including the Arrigetch region, disjunct more than 500 km from its main range (Murray 1974; Cooper 1983). It occurs in warm open forests and near treeline and could be one of the first species extirpated by human visitors because it is so magnificently attractive.

Aphragmus eschscholtzii (a plant in the mustard family) is an Alaska endemic typically found in the moist tundras and high mountains of the southern coast. Two small populations were found on barren and permanently wet limestone sands in the study area. It is disjunct over 600 km from its main range. Other rare arctic-alpine taxa include; Melandrium taimyrense, and Pulsatilla patens on warm and stable bluffs in valley bottoms; Papaver denalii, a few dozen plants occur

at two sites on broken scree at low (and frequently traversed) passes on the highest ridgetops. Also known to occur in the region is Oxytropis koyukukensis, an Alaska threatened species (D. Murray and Batten 1978) and Campanula aurita. While the species mentioned are in themselves extraordinary, more importantly they hint at the richness yet to be discovered.

Lichens and mosses.--Several very rare lichens occur in the Arrigetch valley and indicate that the region will be a great source of new lichen finds (Cooper 1985c). Placidiopsis cervinula was found on a barren limestone slope, and has been found in only two other locations in the world, Mongolia and the Murmansk district of Lapland. Lecanora pachythallina has been found in only one other North American locality, Baffin Island. Several rare arctic mosses also occur including; Andraeaobryum macrosporum on wet to dripping limestone cliffs, and Oligotrichum falcatum on granite boulders in cirques. Other interesting finds for the Alatna River region are reported by B. Murray (1974).

Boreal plant species at their northern limit.--Where the Arrigetch Peaks and Mt. Igikpak plutons contact adjacent rocks warm springs occur in many locations. Some springs such as the large springs on the Reed River are well-known, however most are small and unexplored. The springs provide constant water and a more consistent and warmer microenvironment than is found elsewhere in the the Brooks Range. Many boreal species occur at their most northerly location in Alaska at these springs. In the Arrigetch Creek valley this includes the ferns Dryopteris dilatata ssp. americana (only two plants occur) and Cystopteris montana. The springs in the Arrigetch Creek valley occur within 5 m of the main trail into the valley, and within 50 m of the main camping area. None of the springs have not been explored thoroughly and they will most likely produce numerous very rare or even new species of mosses, and perhaps invertebrate animals.

Human Impact

A number of impacts related to human activities in the Arrigetch Creek valley are outlined below. In these sections I relate the impacts to local ecosystem dynamics and provide suggestions for mitigating impacts.

Campsites.--Heavy use sites such as the main camping area in the Arrigetch Creek valley were denuded of vegetation by the early 1970's. Because as many as half of the visitors to the valley camp in this one campsite, continued use is resulting in soil compaction and erosion which could make revegetation efforts impossible. There is not really enough room in the valley bottom for many alternate campsites nor is a rotation system feasible because almost all visitors come in July and August. The soils of stable valley bottom sites are several hundreds to thousands of years old. The most essential parts of campground location are: (1) that they not be located in or near lichen-dominated stands; (2) that they have no impact on wetland habitats with constant but not standing water. These habitats nurture profuse moss mats which provide almost complete insulation of the soil from the warm summer air resulting in a very shallow thaw depth and permafrost very close to the ground surface. Disturbance of the bryophyte mats can rapidly initiate thermokarst; (3) living trees near the treeline, which are the seed source for treeline expansion, not be disturbed in any manner. It may be necessary to restrict the use of campfires in popular areas to emergency situations.

An alternative and more desirable method of campground selection and development is to eliminate large permanent campgrounds from valley bottoms. Valley bottoms are seen by every visitor and impacts should be minimized and disturbed sites reclaimed. Small campgrounds could be located on active slopes where a small level area occurs below solifluction lobes. Because solifluction lobes are slowly moving downhill, in time they will override the campground and all traces of human disturbance will be eliminated. A system of a dozen campgrounds could be selected throughout the valley and photos used to guide visitors to possible campsites. The Arctic offers unique opportunities to develop non-traditional visitor use guidelines, and any approach that can help eliminate permanent impacts and gives visitors a unique camping experience should be developed.

Trails.--Trails which cross several vegetation types provide exemplary information on which types of vegetation can withstand continuous use and which are rapidly degraded. Trails have significantly impacted lichen dominated ecosystems which occur on granitic bedrock, talus, or moraines, while more moist meadows occurring on limestone show little impact. Trails are developing in the area haphazardly, ignoring ecosystem impacts. Although the original intention was to keep the area "trailless", what must be done now is to survey where people are going within the Arrigetch valley, and determine which trails are having significant impacts on flora, soils or visual qualities. These data can be used to reroute trails.

Humans and animals.--Most animals in the Arrigetch region are unaffected by human activities. Winter trapping and aerial hunting have reduced populations of wolf, lynx and fox. Dall sheep were heavily hunted by natives from Alatna and Allakaket, and by guided operators. The Arctic caribou herd has been severely reduced in numbers and caribou are rarely seen in the area during migration, and very few residents occur. The small mammals are for the most part unaffected. Numerous bear-human confrontations occur every year in the central Brooks Range. During the three summers I spent in the Arrigetch region three bears were shot and killed by tourists who thought that an approaching bear meant an attack. Unfortunately these shootings have been brought

about by a premeditated feeling that bears are aggressive, although most are not. Visitors must be directed not to shoot the bears.

It has been proposed that the use of horses in the area be allowed. Horses were used by early travelers in the region, however they utilized all native feed. The real danger of introducing horses is importing feed which could introduce exotic plants into this pristine region. At present not one non-native species occurs. Some of the vegetation types dominated by grasses probably evolved under a grazing regime as horses and other large mammals were present in Pleistocene Beringia. If horses are to be utilized stands where they can be tethered and allowed to feed must be designated and horses should not be allowed into heavy use areas such as the Arrigetch valley.

DISCUSSION

Many ecosystems in the Arrigetch Peaks region are in an intricate balance controlled by climate change and soil stability. It is essential to utilize an understanding of these factors in producing land-use plans. One of the unique aspects of the central Brooks Range is that in most areas no human-related disturbances have previously occurred. All plant species composing the native flora, and all non-migratory animals composing the fauna are present, and all ecological processes are operating naturally. It is possible to make complete and true inventories and baseline studies of the biological and ecological features and intricacies of the region. It thus provides a unique opportunity to attempt management of a region which is well-known ecologically, and to which increasing visitor use will undoubtedly take its toll.

The most important ecological aspects to consider in planning and preservation include:

1. ecological processes, ie. successions, mass wasting, predator-prey relationships etc.

2. rare and/or significant plant species.

3. lichen dominated ecosystems which are "fragile".

4. ecosystems which are relicts of a past climate and are presently very restricted in their distribution yet may be critical as progenitors of the vegetation of the future.

5. trees near the treeline (both valley-head and valley-side treeline) are seed sources for treeline changes.

6. the insulation layer in ecosystems with continuous permafrost and very shallow depth.

7. large mammals which are subject to human impacts.

8. no exotic plant species be introduced by any means.

Planning which utilizes ecological concepts will restrict some uses and activities, but can supplement or increase the area where many uses occur. For example, because disturbances are naturally common on many slopes, human impact will not be significant in the long term. Evidence of campfires, campsites etc. can be naturally buried in many areas. Because most slope movement (solifluction) takes place in early summer before most visitors arrive, and because the slope processes (except in ravines) are constant and gradual there is little danger of injury. Active areas can be selected as alternative or primary camping areas, and planners can feel confident that the inevitable disturbance will eventually be buried. In addition, many of the dominant plant species on slopes are well-adapted to disturbance and natural revegetation will occur most rapidly.

The transplanting of Cladonia mats for revegetation of severly impacted lichen stands in critical areas has never been attempted, as far as I know. However, the lichen mats are perfect for transplants because: (1) they have no roots; (2) they cling together in mats which are easily lifted, cut and transported; and (3) the same few species (Cladonia stellaris, C. rangiferina, and C. sylvatica) are dominant in these mats almost anywhere in northern Alaska. They can be matched perfectly without the fear of accidental introduction on non-native plant species.

Essential research projects for the Arrigetch Peaks region include; (1) a carrying capacity study to determine resilience of different community types; (2) a monitoring program to determine rates of soil loss from campsite areas; (3) a Cladonia spp. lichen growth rate study to determine recovery rates of lichen dominated vegetation; (4) complete biological surveys of the springs, and other unique habitats.

REFERENCES

Argus, G. W. The Genus Salix in Alaska and the Yukon. Publications in Botany, no. 2. National Museums of Canada, Ottawa, Canada; 1973.

Bliss, L. C., and Gustafson, K. Natural Landmarks of the Brooks Range, Alaska. National Heritage and Conservation Association. Washington, D.C.; 1979: U.S. Department of the Interior.

Braun-Blanquet, J. Plant Sociology, the study of plant communities. (translated, revised, edited by George Fuller and Henry Conard), New York; McGraw Hill: 1932: 439pp.

Cooper, D. J. Arctic-alpine tundra ecosystems of th Arrigetch Creek valley, Brooks Range, Alaska. Boulder, Colorado; PhD Dissertation, University of Colorado, 827pp + tables: 1983.

Cooper, D. J. Palsas, their dynamics and relation to climate change in the Arrigetch Creek valley, Brooks Range, Alaska. Arctic and Alpine Research, submitted, 1985a.

Cooper, D. J. White spruce above and beyond treeline in the Arrigetch Peaks region of the central Brooks Range, Alaska. Arctic, submitted, 1985b.

Cooper, D. J. Lichens of the Arrigetch Creek valley, Brooks Range, Alaska. Bryologist, submitted; 1985c.

Crum, H. A., Steere, W. C. and Anderson, L. E. A new list of mosses of North America north of Mexico. The Bryologist 76: 85-130. 1973.

Garfinkel, H. A., and L. B. Brubaker. Modern climate-tree growth relationships and climatic reconstruction in sub-arctic Alaska. Nature 286: 872-874; 1980.

Guthrie, R. D. and J. V. Matthews. The Cape Deceit Fauna. Early Pleistocene mammalian assemblage from the Alaskan Arctic. Quaternary Research 1: 474-510; 1971.

Hamilton, T. D. Alaskan temperature fluctuations and trends: an analysis of recorded data. Arctic 18: 104-117; 1965a.

Hamilton, T. D. 1965b. Comparative glacier photographs from northern Alaska. Journal of Glaciology 5: 479-485; 1965b.

Hamilton, T. D., Calkin, P. E. and Ellis, J. M. Holocene climatic change, alluviation, and cirque-glacier expansion in the Brooks Range, Alaska. Abstracts with Programs. 95th Annual Meeting, Geological Society of America. 1982; 14 (7): 505-506.

Hopkins, D. M. The paleogeography and climatic history of Beringia during Cenozoic time. Internord 12: 121-156; 1972.

Hopkins, D. M. Sea level history in Beringia during the past 250,000 years. Quaternary Research 3: 520-540; 1973.

Hopkins, D. M., Matthews, J. V., Schweger, C., and Young, S. B. Paleoecology of Beringia. New York; Academic Press; 1982: 489pp.

Hulten, E. Flora of Alaska and neighboring territories: a manual of the vascular plants. Stanford University Press; 1968. 1008pp.

Marshall, R. Alaska Wilderness: Exploring the Central Brooks Range. Berkley; University of California Press: 1970. 173pp.

Matthews, J. V. Jr. Arctic-steppe; an extinct biome? In: American Quaternary Association Abstracts of the fourth Annual Meeting, Tempe; Arizona. 1976: pp. 73-77.

Murray, B. M. Bryophytes and Lichens. In. D. F. Murray ed. Notes on the botany at selected localities in the Alatna and Killik River valleys, central Brooks Range, Alaska. U. S. National Park Service report. 1974.

Murray, D. F. Notes on the botany at selected localites in the Alatna and Killik River valleys, central Brooks Range, Alaska. U. S. National Park Service report. 1974.

Murray, D. F., and Batten, A. Threatened and Endangered plants of Alaska. BLM publication, 1977.

Murray, D. F., Murray, B. M., Yurtsev, B. A., and Howenstein, R. Biogeographic significance of steppe vegetation in subarctic Alaska. International Conference on Permafrost, Fairbanks, Alaska. 1982.

Packer, J. G. A taxonomic and phytogeographical review of some arctic and alpine Senecio species. Canadian Journal of Botany 50: 507-518; 1972.

Pegau, R. E. Growth rates of important reindeer forage lichens on the Seward Peninsula, Alaska. Arctic 21: 255-259; 1968.

Perry, A. H. Recent climatic change-is there a signal amongst the noise. Progress in Physical Geography 8: 111-117; 1984.

Sergin, S. Ya. and Shcheglova, M. S. The climate of Beringia during the glacial epochs: A result of the influence of local and global factors. In V. L. Kontrimavichus, ed. Beringia v Kainozoe, Academy of Science, U.S.S.R., Far Eastern Science Center, Vladivostock. pp. 171-176. In Russian, with English abstract. 1976.

Smith, P. S. The Noatak-Kobuk region, Alaska. U. S. Geological Survey Professional Papaer 192; 1913: 100 pp.

Thomson, J. W. Lichens of the Alaskan Arctic Slope. University of Toronto Press, Toronto, Canada; 1979: 314 pp.

Westhoff, V., Maarel, E. van der. The Braun-Blanquet approach. In. R. Tuxen ed. Handbook of of vegetation science. Part V. Ordination and Classification of Communities. Junk, the Hague; 1978: pp. 617-726.

Young, S. B. Floristic investigations in the "Arctic-steppe" biome. In S. B. Young ed. The environment of the Yukon-Charley Rivers area, Alaska. Contribution from the Center for Northern Studies; 1976: pp. 124-145.

Young, S. B. Is steppe tundra alive and well in Alaska? In Abstracts, American Quaternary Association, 4th annual meeting, Tempe, AZ; 1976b: pp. 84-88.

Yurtsev, B. Forest-steppe meso-landscapes of south-facing slopes in the northern taiga parts of eastern Alaska. Bot Zh. Tom 69: 881-889; 1984a.

Yurtsev, B. Botanical-geographical characteristics of steppe vegetation of interior Alaska. Bot. Zh. 6: 743-752; 1984b.

RARE PLANT MANAGEMENT IN WILDERNESS: THEORY, DESIGN, AND IMPLEMENTATION

Michael P. Hamilton and James P. Lassoie

ABSTRACT: Wilderness areas in the San Jacinto Mountains of southern California were studied to determine how patterns of backcountry recreation have altered populations of rare plant species. Twenty-seven "target rare species" from a flora of 218 were sufficiently rare to justify comparing the extent and nature of recreation conflicts due to trampling, collecting, and habitat degradation. A total of 157 site-specific conflicts were documented, and a series of policies and management actions were designed to isolate and resolve significant conflicts. General guidelines are proposed for incorporating rare plant management into traditional wilderness planning and management approaches.

PERSPECTIVES ON WILDERNESS MANAGEMENT

Are rare plants that occur within designated wilderness adequately protected or preserved? Further, are wilderness managers properly trained to understand natural ecosystems and processes so that they can "preserve its natural conditions" as the Wilderness Act implies they must? This study is concerned with the notion that wilderness cannot be adequately protected from the effects of physical degradation (overuse) without precise, scientific knowledge about the organisms and processes that compose each wilderness ecosystem.

Within the past decade, recreation managers have insisted that most nonmotorized activities in wilderness are inherently benign (Hendee and others 1978). Based on this assumption, the dollars spent on wilderness management are concentrated on regulating the type, extent, and intensity of recreation (Hendee and Stankey 1973). Overuse of wilderness is often defined as levels of recreation activities that either 1) reduce opportunities for solitude by visitors; 2) affect the landscape in ways that visually detract from a visitor's perception of "naturalness" or, 3) deplete the quality or abundance of features such as firewood, water, or campsites (Frissell and Stankey 1972).

A modern approach to wilderness management focuses upon the ecosystems and species of wilderness. Policies and regulations that successfully reduce or eliminate negative effects on populations of species living within a wilderness would fit into the management framework. A small, but increasing number of wilderness areas in California are managed from an ecological perspective because this technical approach requires site-specific knowledge of the resources. Resource management is generally concentrated on land managed for economic benefits, rather than on recreation-centered landscapes. Funding for biotic surveys and population monitoring is rarely allocated for wilderness areas.

Our study emphasized the techniques and approaches used by ecologists and resource managers to identify, classify and monitor rare plant populations, as well as to document an approach to identify recreation conflicts and resolve them within the framework of wilderness management planning and interagency cooperation.

CONCEPTS OF RARE PLANTS AND HABITATS

Wilderness management of rare species is a very recent development. The Endangered Species Act (1982) mandates that no Federal agency can jeopardize, through actions or decision-making, any species and their designated critical habitat once those species are formally declared threatened or endangered. The Act protects those species formally listed by this legislation, and does not include the thousands of species currently recognized as rare and threatened by such organizations as the Smithsonian or the California Native Plant Society (Ayensu and DeFilipps 1978; California Native Plant Society 1984). The political process for "listing" a rare species under the Endangered Species Act is time consuming and costly, whereas rare species are being threatened by developments and human activites at an exponential rate (Soule and Wilcox 1980).

Wilderness managers and other administrators charged with natural areas preservation cannot rely solely upon endangered species legislation to identify those species in need of management solutions. Not only must other natural diversity data sources be consulted, but managers and their staff must be trained in principles of species rarity and endangerment. Such training involves a certain amount of ecological and taxonomic theory as well as a practical background in sampling methods and resource management tools. We have coined the term "floristic management" as a subset of wilderness resource management which deals strictly with the botanical composition of an ecosystem. This study provides a theoretical and practical consideration for managing botanical

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resources including rare and endangered species, by using the San Jacinto Wilderness areas in Southern California as case examples. Equally important, but beyond our scope, are the ecological and faunal components of wilderness resource management. We hope that this floristic basis of management will be applicable, in concept, towards management of these other critical resources.

The Endangered Species Act was written to provide regulatory powers for ensuring the survival and protection of rare species threatened with extinction. Obviously, a species that is endangered or threatened constitutes a special case of rarity. Rarity, per se, does not imply endangerment. Rarity may in fact be a successful strategy for plant species survival under natural conditions. A rare species, according to Drury (1980) either " . . .occurs in widely separated, small subpopulations so that inbreeding among subpopulations is significantly reduced or eliminated, or is restricted to a single population." White (1980) defines rarity as " . . .a condition of relative numbers and distribution of populations and individuals; endangerment is the condition of being vulnerable to extinction." A large body of literature does suggest that low numbers of individuals risk greater chances of going extinct (Terborgh 1974; Diamond 1975; Frankel and Soule 1981; Shaffer 1981). Rareness and endangerment should nonetheless be considered independent until a population is faced with threats to a species' reproductive fitness.

Rarity spans a considerable range of conditions as described by Hardin (1977) and White (1980). They define rarity as a two-dimensional space where species comprise few individuals and/or few sites (populations). The former is a measure of abundance or numbers of individuals, while the latter refers to the number of populations that exist. These two concepts are necessarily vague in that each might imply absolute values (such as the geographic range of populations) or relative values such as the numbers of individuals within a defined boundary (for example within a wilderness).

Relative rarity, in contrast to absolute rarity, deals with the abundances of individuals and populations within a politically defined boundary. In this case, the biogeographic range of a species is not considered; rather, a species' dispersion and abundance within a management area is. Nature preserves and wilderness areas have contrived boundaries, and thus contain a subset of the regional flora and vegetation. The rarity or commoness of each species of an artificially bounded flora can be determined by sampling their abundances using standard methods in plant ecology. If rare species are going to be managed as part of the effort to preserve natural ecosystems, then the status of a particular species within the wilderness boundary is equally important as the species' status throughout its biogeographic range. Where wilderness is concerned, there is a specific mandate to preserve natural conditions, including the perpetuation of rare plant species. At a minimum, a wilderness management plan must include a floristic inventory that identifies threatened and endangered plants. Given the major assumption about the benign nature of recreation impacts, management agencies will conduct surveys for rare, threatened, or endangered species, only to stop short of implementing their findings into the day-to-day management activities. So are wilderness lands adequately managed to protect rare species from human effects?

A SYSTEM FOR DEVELOPING RARE PLANT MANAGEMENT APPROACHES

In order to answer this question, a case study was designed. The San Jacinto Mountains are the northernmost portion of the California Peninsular Mountains in southern California. Reaching elevations approaching 11,000 feet above sea level, the coniferous forest ecosystems have been climatically, geographically, and biologically isolated from the Sierran and Mexican ranges since the late pleistocene (Raven and Axelrod 1978). Consequently, numerous species can be considered rare not only due to a constriction of their prehistoric habitats, but also by various degrees of endemic speciation, which has occurred within several plant families.

Two designated wilderness areas are located at higher elevations of these mountains, one being managed by the California State Department of Parks and Recreation, and the other by the U.S. Department of Agriculture, Forest Service. They are contiguous and provide a unique opportunity for comparisons between two distinct approaches to resource management and visitor regulation within a wilderness setting. Neither administration has surveyed its lands for rare plants or animals, or for that matter, compiled a floral list of species occurring within the respective management jurisdictions. Objectives and methodologies of this research project were:

1. To complete a floral inventory for each wilderness area that includes a compilation of information on localities, ranges and relative abundances (using standard ecological and systematic methodologies described in Mueller-Dombois 1974; Munz 1974; Hanawalt and Whittaker 1976; Smartt 1978; and Kessell 1979).
2. To apply a series of rarity criteria to this flora (Drury 1980; California Natural Diversity Data Base 1981; California Native Plant Society 1984).
3. To characterize the nature of recreation uses in such a way as to determine conflicts between rare species and recreation impacts in the wilderness. Conflicts in this case will be defined as i) trampling within populations, ii) collecting of flowers, seeds or bulbs, iii) grazing by cattle and recreational stock, and iv) soil erosion that disrupts plant habitats.
4. To develop a set of policies and management activities to mitigate existing impacts to rare plants by decreasing or eliminating selected rare plant/recreation conflicts. These policies

will then be installed within existing management planning frameworks and planning approaches for overall wilderness management by each agency.

5. To develop a series of useful criteria applicable to other wilderness and natural areas where the maintenance of rare species populations is mandated.

THE BIOTIC DIVERSITY DATA BASE

Two hundred fifteen woody and herbaceous vascular plant species were collected during the course of this study (table 1). From 1979 to 1983, a thorough floristic survey was completed for 20,000 acres of wilderness between the elevations 7,500 ft (2,500 m) and 10,804 ft (3,602 m). All populations of plants were mapped on overlays of color aerial photography at a scale of 1:2,000 (1 ft = 1 mile). Additional information was recorded in the format of 250, 1/4 acre (1/10 ha) plots that summarized the physical and biotic attributes of plant species habitats. Plots were located using a stratified random sampling methodology described by Smartt (1979). Important ecological parameters included physiography (elevation, slope, aspect, solar radiation intensity), overstory composition (dispersion, basal areas, age class distribution, fire history from scars), and understory composition (percent abundance by species, percent coverage by species). Gradient nomograms (Kessel 1979) for each species based upon elevation, habitat, and importance value were plotted.

All species were then classified according to three major lists based upon each species' known geographic range and their observed abundances within the study site. Within wilderness, rarity was determined to be any species whose populations occurred in less than 5 percent of the 1/10 ha plots, or whose relative cover was observed to be consistently under 5 percent of other co-occurring species within a plot. The three lists are organized as follows:

List 1--Regional Rarity

1. Species widespread throughout their ranges but rare within the San Jacinto Wilderness.
2. Species endemic to the California Floristic Province (Raven and Axelrod 1978) but rare within the San Jacinto Wilderness.
3. Species either disjunct or at the limits of their range but rare within the San Jacinto Wilderness.
4. Species endemic to southern California occurring within the San Jacinto Wilderness.
5. Species endemic to the San Jacinto Mountains (including the nearby Santa Rosa Mountains).

List 2--Local Rarity

1. Widespread (without a distinct population boundary) in the San Jacinto Wilderness, found in greater than 5 percent frequency.
2. Widespread in San Jacinto Wilderness, found in less than or equal to 5 percent frequency.

Table 1.--Summary of plant species by geographic distribution, within-wilderness abundance, and growth form in the San Jacinto Wilderness areas

Geographical Distribution	Grass-like	Trees	Shrubs	Herbaceous perennials	Annuals	Total
WIDESPREAD						
common	17	9	10	50	6	92
rare	6	1	3	30	3	43
CALIFORNIA						
common	0	1	3	8	0	12
rare	1	0	0	9	0	10
SOUTH. CALIF.						
common	1	0	0	32	0	33
rare	0	0	2	13	0	15
SAN JACINTO						
common	0	0	1	4	0	5
rare	0	0	0	3	0	3
DISJUNCT						
common	0	0	0	0	0	0
rare	0	0	1	0	1	2
	25	11	20	149	10	215

3. More than two distinct populations, found in greater than 5 percent frequency.
4. More than two distinct populations, found in less than 5 percent frequency.
5. Two or less populations, found in less than 5 percent frequency.

List 3--Local Endangerment

1. Populations isolated from impacts.
2. Populations near impact (usually).
3. Less than or equal to 50 percent of the populations are receiving impacts.
4. Greater than 50 percent of the populations are receiving impacts.
5. Population is extinct or presumed extirpated.

Species classified in the first three categories are rare based on their overall infrequent occurence and/or abundance within the wilderness study site. This determination is obviously independent of their potential occurences outside of the San Jacinto Wilderness. The last two categories (4 and 5) emphasize species with highly restricted geographical distributions, a measurement independent of within-wilderness abundance and distribution measurements. All five categories are ordered by decreasing geographic range. Such a priority is useful for managers who must decide how to allocate management activities for rare plant management. The flora is further classified within each of the five Regional Rarity categories by hierarchical divisions for the local or within-wilderness abundance/dispersion status.

The endangerment categories also fit the observed situations that all of the rare taxa are currently experiencing. An impact in this case occurs if a trail passes through a population and individuals are clearly trampled, if it is obvious that humans have collected from or vandalized a population or have removed plants for rock climbing, or if human-caused disturbance to the landscape has created physical changes which in turn affect rare plant habitats and populations. The extinction category was designed to include species identified by Hall (1902) but presently missing from the wilderness.

One hundred twenty taxa were classified as rare according to the categories in List 1. List 2 plants indicated species whose Local Rarity is classified as either few populations/low numbers or two or less total populations within the wilderness are considered "target rare species," and are described in more detail in the next section. List 3 plants which indicate significant impacts to more than 50 percent of the populations are also considered "target rare species" and are discussed in the next section.

A complete species list and summary of rarity classifications is available upon request from the senior author.

RARE SPECIES MANAGEMENT TARGETS

Plant species that fall within categories 4 and 5 of all three lists have been designated "target rare species" and are considered for priority management actions.

Twenty-seven rare species fall within one or more of the six categories. Special sampling and mapping techniques were used to develop additional ecological information (Hamilton 1983). Plant communities and habitats for these species were classified, observed, and potential habitats were mapped, and a study of the flowering and growth phenology initiated. Annual monitoring of the 27 species was initiated in 1982, and guidelines for institutionalizing the program are now complete (Hamilton 1985). Specific management actions for these species are summarized later in this report.

RARE PLANT AND RECREATION USE CONFLICTS

In addition to a site-specific data base of rare plant occurrences, determining rare plant/recreation conflicts requires the development of a dispersed recreation model for the entire study area. Site-specific maps of visitor distribution and density patterns were developed from standard wilderness permit logs maintained by each wilderness administration. Wilderness permits have been required for recreation use within the San Jacinto Mountains since 1970, and information on group size, trails used, campsite or camping zone used per night, and length of trip has been compiled and archived by each agency for the past 15 years. A summary of this use for 1972-82 is presented in table 2. Trail corridors and overnight camping zones were mapped as overlays on the 1:2,000 scale color aerial photography so that recreation use could be directly related to rare plant population locations. Visitor use densities were classified into five scales of use, and only wilderness localities experiencing the two highest density categories of recreation usage (50 to 100 users per site per day, and less than 100 users per site per day) were targeted for secondary plant surveys. Conflicts between observed rare plant populations and high density recreation were noted, and a summary of these occurrences appears in table 3.

A total of 157 site-specific conflicts were noted and described using this process. Conflicts included trampling along trails, trampling campgrounds and scenic areas, plant collecting without permits, plants or populations within proximity to impacts, impacts resulting from grazing horses (including the release of exotic plants from horse dung), and impacts due to rock climbing. Other impacts which no doubt have an influence include air pollution, wild fire (or lack of it), and fire suppression activities.

Table 2.--Summary of the mean monthly overnight visitation for 13 years (1970-83) within the San Jacinto Wilderness areas (State and Federal)

Location	J	F	M	M	M	J	J	A	S	O	N	D
Round Valley	574	520	904	586	751	3321	2851	2844	1041	1316	1264	653
Deer Springs	34	43	12	33	268	255	259	262	173	99	119	28
Little Round	24	11	27	62	133	317	505	509	502	145	192	57
Peak	24	13	76	21	128	81	93	143	145	63	90	60
USFS Zones	150	150	179	362	1564	3463	2740	2634	1853	1520	968	277
Total	806	737	1198	1064	2844	7437	6448	6392	3714	3132	2633	1075

Most conflicts were spatially clustered, due in part because several rare plant habitats were limited to small sites of unusual or restricted environmental conditions. In these unique habitats it was not uncommon to find several species of rare plants growing adjacent to one another. Alpine species occupying rock crevices on peaks and popular climbing sites, or concentrations of rare annual plants inhabiting the narrow shoreline of a subalpine vernal pool, are typical examples of rare communities of plants experiencing significant trampling impacts due to unrestricted recreational use.

POLICY ANALYSIS AND MANAGEMENT ACTIONS

The development of a comprehensive and site-specific data base of rare plant information has only limited value to a wilderness manager unless a clear set of policies is developed for determining management actions relevant to rare plant/recreation use conflicts resolution. Policy development is in fact relevant to all aspects of wilderness management (Fish and Bury 1981). The Wilderness Acts (Federal and California) suggest policy guidelines, but the responsibility for interpretation and development of policy resides with the local agency such as the National Forest, and often at the District level as is the case for the San Jacinto Wilderness. Similarly, the District Superintendent at the Mount San Jacinto State Park/Wilderness sets policy for activities within the State Wilderness area, which may subsequently be formalized as regulation by the California State Park Commission. For each wilderness management agency in the San Jacinto Mountains, resource management has been directly equated with visitor management.

Although a formal plan for managing the Federal wilderness was published in 1980, it specifically did not deal with natural and ecological resources. Historical and outdated information was used to tentatively describe vegetation and species. Similarly, the state park wilderness managers have not, traditionally, incorporated resource information into their visitor management prescriptions, although that situation has changed with the newly published management plan (California Department of Parks and Recreation 1984). This new plan, written in cooperation with the senior author, includes an extensive section on resource management, and specific policies for resolving rare plant/recreation conflicts.

Table 3.--Summary of rare species conflicts

Type of Conflict	Site Specific Conflict	
	State Park	USFS Wilderness
Trampling along trails	37	32
Trampling in campgrounds	24	21
Picked by collectors	2	2
Removed by rock climbing	0	12
Within proximity to recreation	12	15
Total	75	82

Rare plant populations constitute an important part of wilderness values and their consideration in management planning is specifically mandated by State and Federal legislation. It is therefore important that conflicts with rare plants be minimized or eliminated where possible. It is also understood that interactions between recreationists and plants are impossible to avoid and a certain amount of plant degradation is inevitable within any wilderness. Considering that the rarity of plants can be hierarchically classified, and that certain species are spatially and numerically more or less rare than others, the following policies for developing management actions should be considered:

1. Recreation conflicts with species of the most critical rarity (categories 4 and 5 on Lists 1, 2, and 3) should be reduced to levels consistent with naturally occurring impacts such as herbivore browsing. Additional studies should be conducted to examine populations and habitats of target rare species nearby known concentrations of recreational activities, which are not directly affected by this use.

2. Rare plants of limited distribution (geographically) but of stable population sizes should be considered for management action. Species with wide distributions (within wilderness), unless dependent upon a critical habitat, can sustain higher levels of impact than localized or restricted populations.

3. Areas within a wilderness that support a concentration of rare species (for example unique meadow or riparian habitat) should be considered for management action over areas containing few or a single rare species population, unless the single species falls within the categories indicated in number 1 above.

4. Passive means of eliminating or reducing recreation impacts are preferable over direct regulation or exclusion of the public. Passive means include management actions such as diverting trail corridors, public interpretation to discourage trampling or taking of sensitive species, campsite and fire site removal or relocation.

5. Active or regulatory means of eliminating rare plant conflicts should be considered if passive means still threaten the survival of target rare plants. Active management actions include zoned carrying capacities, no-camping zones, and restricted travel zones.

6. Public interpretation of rare species conservation should be encouraged at trailheads and visitor centers, and wilderness staff should be fully aware of rare plant conflicts and the goals of rare plant management.

7. Long-term ecological monitoring of target rare plant populations should be considered to assess the effectiveness of management actions, and to determine the overall dynamics of these unique plant populations.

Each of these policy goals must be explicitly formulated before specific management actions can be described and implemented. The wilderness management planning process should incorporate rare species issues and describe the extent of rare plant/recreation conflicts. Wilderness administrators should formulate a prioritized list of management actions to systematically deal with conflicts on a case-by-case basis. A variety of tools and resources can be utilized to cost-effectively implement management actions. In the case of the San Jacinto Wilderness areas, successful strategies have included trail closure where redundant trail systems entered rare plant populations. Public access via trail to a unique plant community (vernal pool) was eliminated, including the removal of the place name from trail signs, maps, and interpretive materials. In another case, an entire wilderness campground was relocated to another site several miles away. Other featured actions included meadow rehabilitation, new trail construction, elimination of a seasonal ranger station from a meadow edge, and local public lectures on rare plant issues.

DATABASE MANAGEMENT AND WILDERNESS MANAGEMENT PLANS

Reconciling the conflicts inherent in preserving and protecting rare plant populations within an extensively used recreation area should become a relatively routine component of wilderness management once a framework of appropriate policies and management actions has resolved initial inconsistencies. The early phases of identifying conflicts after an adequate biotic diversity data base has been developed are relatively straightforward. The costs of correcting conflicts will certainly vary depending upon the situations encountered, but innovations on the part of managers can reduce costs through the use of low-cost labor (work camps, volunteers, state Conservation Corps, etc.). Other strategies might include an interagency cooperative agreement to share expenses for data base development, and the use of local university students and faculty, as well as local environmental organizations, to share in data collection, indexing, and literature reviews.

Resource management planning for rare plant protection is a new idea, and few systems have been designed for this express goal (The Nature Conservancy 1972; Simmons and others 1976; Herrmann and Bratton 1977; Picket and Thompson 1978; Synge and Townsend 1979; Morse and Henefin 1981). Rare species management need not preclude multiple land uses.

Recreation impact management and research is dependent upon the sorts of baseline information needed to establish rare species data bases and recreational conflicts analyses. Soil mapping, surveys of understory vegetation at disturbed and undisturbed sites, response of vegetation to trampling, and visitor use patterns are necessary information for predicting rates of site deterioration and revegetation--all important

parameters for maintaining visual quality for backcountry recreationists (Boden and Ovington 1973; Merriam and Smith 1974; Bratton and others 1978; Cole 1981).

It should become increasingly obvious that developing a set of policies and programs for rare plant management serves as a beginning for an entirely new dimension in wilderness multiple-use, which need not jeopardize or conflict with other established and traditional uses. Coordination of such efforts is best accomplished through co-operative agreements between wilderness agencies and the university and government institutions that stand to gain from using the scientific values of wilderness ecosystems. Such non-consumptive uses of Federal and State lands are likely to persist as an enduring justification for wilderness as a land designation that is independent of economic influences common to landscapes whose management is dependent upon a consumptive marketplace.

CONCLUSIONS

Management of wilderness areas in the United States has generally concentrated on the regulation of recreation use to control excessive crowding and physical degradation of popular areas. There has been a long tradition, supported by congressional and state legislation, for the maintenance and management of undisturbed ecosystems and "natural processes" within the wilderness landscape. However, few wilderness managers are equipped with adequate information, monitoring procedures, or technically trained staff to make an evaluation of the overall ecological effects of dispersed or backcountry recreation patterns. Consequently, limited populations and communities of locally and regionally rare plants species have experienced declines in abundance and distribution directly attributable to recreation-related activities and wilderness management decisions.

REFERENCES

Ayensu, E.S.; DeFillipps, R.A. Endangered and threatened plants of the United States. Washington, DC: Smithsonian Institution and the World Wildlife Fund; 1978. 432 p.

Boden, R.W.; Ovington, J.D. Recreation use patterns and their implications for management of conservation areas. Biological Conservation. 4:265-270; 1973.

Bratten, S.P.; Hickler, M.G.; Graves, J.H. Visitor impact of backcountry campsites in the Great Smokey Mountains. Environmental Management. 5:431-442; 1978.

California Department of Parks and Recreation. Management plan for the Mount San Jacinto State Park Wilderness. July 1985. California Department of Parks and Recreation, Sacramento. 89 p.

California Native Plant Society. Inventory of rare and endangered plants of California. Special Publication No. 1, 1984. 89 p.

Cole, D.N. Managing ecological impacts at wilderness campsites: an evaluation of techniques. Journal of Forestry. February: 16-19; 1981.

Diamond, J.A. Island biogeography and the design of nature preserves. In: May, R. M. ed. Theoretical Ecology: Principles and Applications. Philadelphia, PA: Sanders, 1976. 324 p.

Drury, W.H. Rare species of plants. Rhodora. 82:3-48; 1981.

Fish, B.C.; Bury, R.L. Wilderness visitor management: diversity and agency policies. Journal of Forestry. September: 608-612; 1981.

Frankel, O.H.; Soule, M.E. Conservation and evolution. Cambridge, U.D.: Cambridge University Press, 1981. 327 p.

Frissell, J.F.; Stankey, G.H. Wilderness environmental quality and the search for social and ecological harmony. proceedings; 1971 June 1-3; Society of American Foresters, Hot Springs, Arkansas: 1972: 170-183.

Hall, H.M. A botanical survey of San Jacinto Mountain. University of California Publications in Botany. 1:1-140; 1902.

Hamilton, M.P. A floristic basis for the management of rare plants and their communities in the San Jacinto Mountains, California. Ithaca, NY: Cornell University; 1983. 183 p. Dissertation.

Hamilton, M.P. Management plan for the James San Jacinto Mountain Reserve. Riverside, CA: University of California Natural Reserve System, James San Jacinto Mountains Reserve; 1985. 85 p.

Hanawalt, R.B.; Whittaker, R.H. Altitudinally coordinated patterns of soils and vegetation in the San Jacinto Mountains, California. Soil Science. 121:114-121; 1976.

Hardin, J.W. Vascular Plants: Introduction. In: Cooper, J.E.; Robinson, S.S.; Funderburg, J.B. Endangered and threatened plants and animals of North Carolina. Raleigh, N.C.: North Carolina State Museum of Natural History; 1977, 55-63.

Hendee, J.C.; Stankey, G.H. Biocentricity in wilderness management. Bioscience. 23(9):535-538; 1973.

Hendee, J.C.; Stankey, G.H.; and R.C. Lucas. Wilderness management. U.S. Department of Agriculture, Forest Service Misc. Publication No. 1365; 1978. 348 pp.

Herrmann, R.; Bratton, S.P. Great Smokey National Park as a biosphere preserve: a research monitoring perspective. 1977. Research/Resources Management Report N. 23, U.S. Department of the Interior, National Park Service, Atlanta, GA.

Kessell, S.A. Gradient modeling: resource and fire management. New York: Springer Verlag; 1979. 223 p.

Merriam, L.C.; Smith, C.K. Visitor impact on newly developed campsites in the Boundary Waters Canoe Area. Journal of Forestry. 72:332-334; 1974.

Meuller-Dombois, D.; Ellenberg, H. Aims and methods of vegetation ecology. New York: Wiley Interscience; 1974. 387 p.

Morse, L.E.; Henefin, M.S. Rare plant conservation. New York: New York Botanical Garden; 1981. 267 p.

Munz, P.A. A Flora of Southern California. Berkeley: University of California Press, 1974. 782 p.

Pickett, S.T.A.; Thompson, J.N. Patch dynamics and the design of nature preserves. Biological Conservation. 13:27-37; 1978.

Raven, P.H.; Axelrod, D.I. Origins and relationships of the California flora. UC Publications in Botany. 72:1-133; 1978.

Shaffer, M.E. Minimum population sizes for species conservation. Bioscience. 31(2):131-134; 1981.

Simmons, J.B.; Beyer, R.I.; Brandham, P.E.; Lucas, G.A.; Parry, V.T.H. Conservation of threatened plants. New York: Plenum Press; 1980.

Smartt, P.F.M. Sampling for Vegetation Surveys: A flexible systematic model for sample locations. J. of Biogeography. 5:43-56; 1978.

Soule, M.E.; Wilcox, B.A. Conservation biology. Sinauer, Ma: Sinauer Press, 1980. 395 p.

Synge, H.; Townsend H. Survival or extinction. Kew, U.K.: Bentham-Moxon Trust, Royal Botanical Gardens; 1978. 268 p.

Terbough, J. Preservation of natural diversity: the problems of extinction-prone species. Bioscience. 24(12): 715-722; 1974.

The Nature Conservancy. Preserve management handbook. 1972. Unpublished paper on file at The Nature Conservancy, Arlington, VA.

White, P.S. Reports on Rare, Threatened and endangered vascular plants: discussion and guidelines. Research/Resources Management Report No. 33. Gatlinburg, Tenn.: U.S. Department of the Interior, National Park Service, Southeast Region, Uplands Field Research Laboratory, Gatlinburg, Tenn.; 1980. 89 p.

RESPONSES OF VEGETATION TO DIFFERENT WILDERNESS MANAGEMENT SYSTEMS

Dale A. Thornburgh

ABSTRACT: The vegetation has been monitored since the early 1960's, at several locations in the wilderness areas of the North Cascade Mountains of Washington for the purpose of determining the impact from different wilderness management systems "No Management", "Control of Pack Stock", "100-foot No Camping Limit", "Day Use Only", "Education" and "Designated Campsite". After twenty-three years of monitoring, devegetation continued to increase at all areas under the different wilderness management systems, except the "Designated Campsite" system which controlled the amount and location of the impact in the subalpine meadows.

INTRODUCTION

In the 1950's and early 1960's visitors to the wilderness areas of the Pacific Northwest were free to use the backcountry at their own discretion. They could camp at any location, build campfires anywhere and graze packstock without restrictions. In the mid 1960's the first guidebook to the Cascade Mountains of Washington mentioned that a few areas were becoming "crowded" such as "Image Lake" and "Cascade Pass", however, only one guidebook recognized that overcrowded areas were becoming impacted and warned campers of the "scars and trails in the fragile meadows" at Image Lake (Crowder and Tabor 1965; Marshall 1966). At this time wilderness managers either were not aware of or were not concerned about potential impact to the vegetation.

In the early 1960's studies were made at several locations in the North Cascade Mountains of Washington for the purpose of determining the type and amount of impact resulting from the increasing unregulated use under the "No Management" system prevalent at that time (Thornburgh 1962). Following these initial studies, wilderness managers began to control wilderness use at Image Lake in 1963, using a succession of different wilderness management systems, "No Management", "Control of Pack Stock", "100 foot No Camping Limit", "Day Use Only" and "Designated Campsite". The objective of this paper is to relate the changes in vegetation at Image Lake to these different wilderness management systems. The results at Image Lake are compared to the response of vegetation to similar wilderness management systems used at other areas in the North Cascades of Washington and in several wilderness areas in Northern California.

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METHODS

Five areas were initially selected in the North Cascade Mountains to study the vegetational impact resulting from wilderness use. Two areas of known high use, Image Lake and Cascade Pass, were selected as the main study areas. The other areas, Whatcom Pass, Park Creek Pass and Easy Pass, with less accessibility and less use were selected to supplement the main study areas. The study areas are located in the sub-alpine zone, consisting of a mosaic of forest patches and tree clumps in a park-like setting of shrubby and herbaceous meadows. All study areas are located between 5000 and 6000 feet in elevation. The plots located at Image Lake, Cascade Pass, Park Creek Pass, and Easy Pass were established while these areas were initially under a "No Management" system. Plots located at Whatcom Pass were established two years after the wilderness management system was changed from a "No Management" to a "Day-use Only" system.

IMPACT OF THE "NO MANAGEMENT" SYSTEM

Before the earliest management control at Image Lake in the Glacier Peak Wilderness Area was put into effect in 1963, wilderness users were under a "No Management" system. Visitors could camp at any location, build fires at any spot and graze packstock without restrictions. In 1961, 120 permanent vegetation cover plots were systematically established in the Image Lake Basin. Several photo points were established and the location and condition of devegetated areas and impacted vegetation were mapped. Under the completely laissez-faire system then in existence, all wilderness user activities that usually result in impact to the vegetation and complete devegetation to some areas occurred within 200 feet of the edge of the lake (fig. 1).

Camping primarily occurred at one location and caused a fairly large area of completely denuded vegetation. Other camping areas with smaller devegetated spots were scattered around the lake. The bulk density of the soil at the camping sites averaged 1.07 gm/cc, more than twice the 0.5 gm/cc of undisturbed soil. The most obvious effect of use in the zone of impact surrounding the lake was the change in plant species composition resulting from trampling and grazing. The undisturbed areas

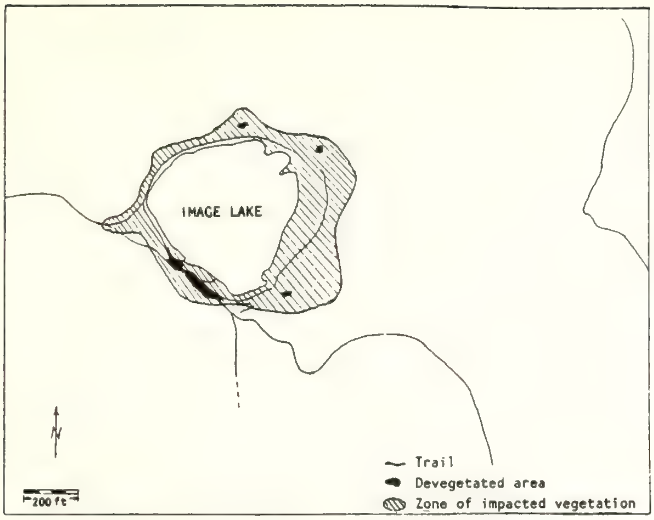

Figure 1.--Trails, devegetated areas and zone of impacted vegetation found in 1961 at Image Lake, Glacier Peak Wilderness.

were dominated by Phyllodoce empetriformis, Vaccinium deliciosum, Valeriana sitchensis, Phlox diffusa, Veratrum viride, Lupinus arcticus, Polygonum bistortoides, Anemone occidentalis, Gentiana calycosa and Pedicularis contorta, all with showy flowers. The vegetation in the impacted areas was low in stature and dominated by Antennaria lanata, Aster foliceus, Potentilla flabellifolia, Agrostis idahoensis, Deschampsia atropurpurea and Luetkea pectinata with from 20-40% of the area consisting of bare ground. Very few of the plants in the impact area developed flowers.

The same type of impact was occurring at other areas throughout the North Cascade Mountains: Cascade Pass, Park Creek Pass, Whatcom Pass and Easy Pass. At these areas impact zones consisting of deteriorated meadow vegetation, a network of social trails, and denuded camping sites were developing at the focal points. At the Park Creek Pass area, the most obvious impact on the vegetation was the network of social trails and devegetated campsites that had developed under a "No Management" system (fig. 2).

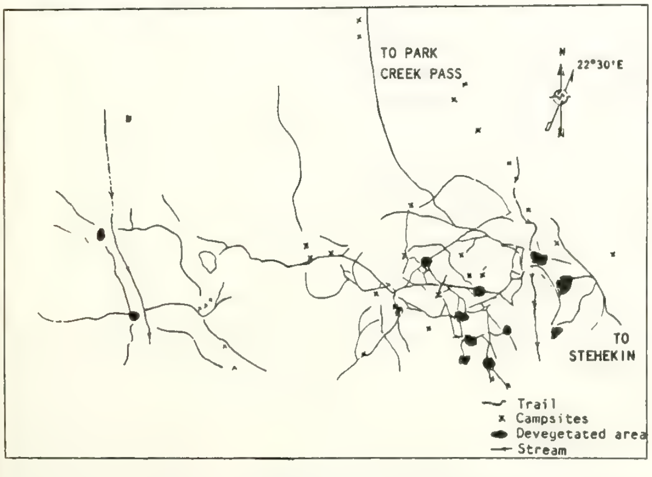

Figure 2.--Trails, campsites and devegetated areas in 1969 at Park Creek Pass, North Cascades National Park.

By 1969 a maze of social trails interconnected a total of 46 campsites. Between 1968 and 1971 an average of six new campsites were established each year. Throughout the campsite and trail zone the vegetation was being impacted with the most sensitive vegetation eliminated first, followed by more resistant species as indicated in table 1.

Table 1.--Order of vegetation sensitivity to impact in the Vaccinium/heather meadows of the Park Creek Pass area

Valeriana sitchensis	Most sensitive species
Pedicularis spp.	to impact
Eryothronium grandiflorum	
Polygonum bistortoides	
Erigeron peregrinus	
Phyllodoce empetriformis	
Cassiope mertensiana	
Luetkea pectinata	Most resistant to impact.
Antennaria lanata	On very heavily used
Carex spectabilis	campsites these species
Vaccinium deliciosum	are the only ones present.

In northwestern California, several small roadless areas were designated as official wilderness areas in 1984, which previously were administered as unmanaged areas. In one such area, the 12,000 acre Russian Wilderness Area, there is a total of 30 lakes where, under the "No Management" system, 96% of the visible impact has occurred immediately adjacent to the lakes, usually in the most sensitive vegetation. At the heavily used lakes, from 50 to 75% of the lake margin vegetation has been denuded. Eliminated species include Vaccinium scoparium, Vaccinium arbuscula, Phyllodoce empetriformis, Leucothoe davisiae, Ledum glandulosum, Kalmia Polifolia, Polygonum bistortoides and Carex spp.

Conclusions based upon monitoring permanent plots and vegetational impact surveys in the North Cascades of Washington and roadless areas of N.W. California indicate that the "No Management" wilderness system results in ever increasing impact to the vegetation at scenic focal points. This impact causes a reduction in wilderness values of the area and often produces almost irrevocable changes in the vegetation communities. After 24 years, some of the heavily impacted areas adjacent to Image Lake are still mostly devoid of vegetation.

"CONTROL OF PACK STOCK" SYSTEM

The earliest management control at Image Lake was put in effect in 1963. At that time the wilderness managers constructed a horse trail around the upper lake basin and developed a horse users' camping area below the lake basin (fig. 3). It was the manager's belief that unregulated horse use in the immediate lake basin was responsible for the major impact on vegetation (DeWitz 1966).

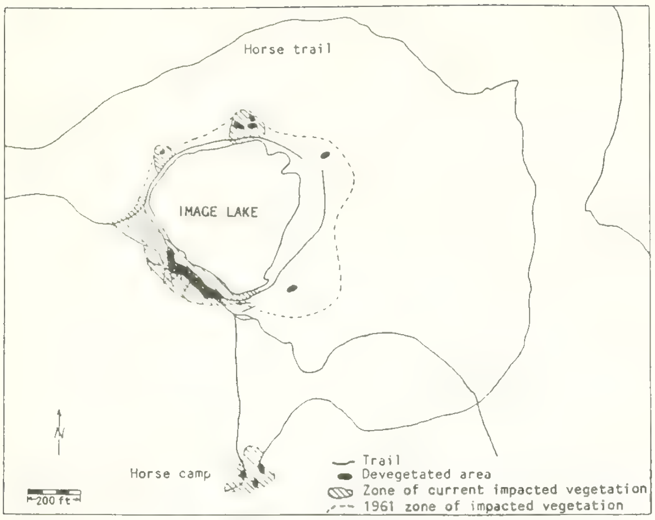

Figure 3.--Trails, devegetated areas and zone of impacted vegetation found in 1966 at Image Lake, Glacier Peak Wilderness.

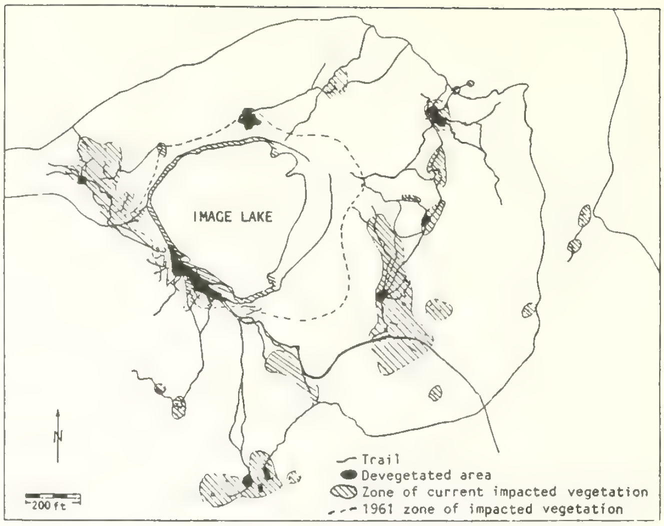

Figure 4.--Trails, devegetated areas and zones of impacted vegetation found in 1971 at Image Lake, Glacier Peak Wilderness.

The permanent plots at Image Lake were remeasured and vegetational impact surveyed in 1966. Vegetational changes indicated that impact had lessened or stabilized on a portion of the 1961 impact zone around the lake and was increasing on vegetation in 40% of the area. In a portion of the 1961 impacted zone adjacent to the lake rim, there was less noticeable trampling impact and an increase in the amount of plants that developed flowers, particularly <u>Potentilla flabelliafolia</u>, <u>Aster folicaceus</u> and <u>Antennaria lanata</u>. The amount of bare ground remained at the same percentage as in 1961. In the areas around the backpacker campsites on the southwest and northwest sides of the lake, the impact on the vegetation and percent of bare ground continued to increase (fig. 3). Within three years after the development of the horse camp, heavy impact had occurred in the designated horse users camping area.

"100 FOOT LIMIT" MANAGEMENT SYSTEM

In 1967 the wilderness managers at Image Lake imposed a "No Camping Within 100 Feet Of the Rim Of the Lake" as a new management system in an attempt to reduce the impact immediately adjacent to the lake. Four new toilets were constructed away from the lake to help disperse the campers. At the peak of the backpacking season a wilderness ranger was on location to enforce this "100 foot No Camping" regulation. A 1971 resurvey of the vegetation and plots indicated that within four years after this system was put into effect, the number of campsites and amount of vegetational impact had greatly increased (fig. 4).

The results of this "100 foot No Camping" system were to increase and spread the zone of impact and devegetated sites into a wider area around the lake. Even with the spacial limit placed upon camping, a sufficient number of campers still used the older campsites adjacent to the lake, to maintain the camping and trampling impact enough to prevent any vegetation recovery in the campsite areas. This use continued even though the "No Camping" rule was enforced by the occasional visit of a wilderness ranger. In addition, the impact immediately adjacent to the rim of the lake also increased around 60% of the lake. On the south and west side of the lake, the amount of exposed bare soil increased up to almost 90% in some areas, apparently due to an increase in fishing and swimming activities. To monitor this larger area of impact, in 1971, an additional 360 permanent plots were established in both impacted and undisturbed vegetation.

In the Marble Mtn. Wilderness Area of Northern California camping is also restricted by a "100 ft. or 200 ft. No Camping" limit at most of the lakes. However, at 14 lakes surveyed in 1975, 90% of the denuded campsites and most of the impacted vegetation were immediately adjacent to the lakes and well inside the "No Camping" distance limit (Thornburgh 1975). My conclusion based upon the vegetation impact observations at Image Lake and the survey in the Marble Mtns. is that the "100 Foot No Camping Limit" (enforced or not enforced) does not reduce impact adjacent to the lake and in some cases it just results in increasing the areal extent of impacts.

"DAY USE ONLY" SYSTEM

At Image Lake in 1978 the wilderness manager imposed a "Day Use Only" system. No camping was allowed in the lake basin and all users were requested to camp in another basin two miles from Image Lake. Revegetation of some of the devegetated campsites and network of trails was also started at this time. Observations from a remeasurement of the permanent plots and survey of the impacted areas in 1981 indicated that in the majority of the impacted areas the vegetation coverage and species composition had not changed from 1971 to 1981. Thus, in these areas impact had not increased, but the vegetation had not recovered except in a few areas that were artificially

revegetated. In the vegetation immediately adjacent to the edge of the lake, however, there was an increase in vegetation impact. Apparently this increase was caused by day users that visit the lake and engage in activities immediately adjacent to the lake, such as swimming and fishing.

The "Day Use Only" system at scenic focal points is also used in the North Cascades National Park. Permanent plots were established and a survey of impact was completed in the early 70's at three key focal points, Cascade Pass, Easy Pass and Whatcom Pass. The survey results showed that all three of these areas had suffered heavy and fairly permanent vegetation impact under the previous "No Management" system. Resurveys of these three areas in the early 1980's indicated that vegetational changes resulting from wilderness users had been reduced under the "Day Use Only" system except at the exact crest of the summit, where day users generally stop to rest and/or view the scenic sights.

The conclusions drawn from these two sets of observations is that "Day Use Only" systems greatly reduce vegetational impact, except at the exact focal point that attracts the user, the crest of the pass or the rim of the lake.

"DESIGNATED CAMPSITE" SYSTEM

In 1982 the wilderness managers responsible for the Image Lake area changed the management system from "Day Use Only" to "Designated Campsites". Camping was again permitted in the lake basin, but all campers were required to camp in the designated campsites southeast of the lake. No camp fires were permitted in the lake basin, even at the designated campsites. Horses were restricted in the lake basin, day use hitching posts were provided on the rim of the basin. Revegetation at previously denuded campsites and social trails was continued on a limited basis. Enforcement was limited to an occasional visit by a wilderness backcountry ranger.

In 1984 the permanent plots were remeasured and a general vegetation and impact survey was conducted in the area. The results of this remeasurement and survey showed that current vegetational impact was limited to the designated campsites below the lake and to two small areas in the lake basin which apparently received a limited amount of use during 1984 (fig. 5). The trails illustrated in figure 5 are the active trails that continue to be used by wilderness hikers. The large number of social trails that appeared in the 1981 survey (fig. 4) had been artificially revegetated or had revegetated naturally. All of these older now revegetated trails were still highly visible, but were not currently being trampled. The impact on the vegetation that occurred under the previous management systems was still highly visible in 1984, especially inside the 1961 zone of impact and at the campsites that were developed from 1968 to 1978.

It is readily apparent that the "Designated Campsite" system reduced the vegetation impact at the highly

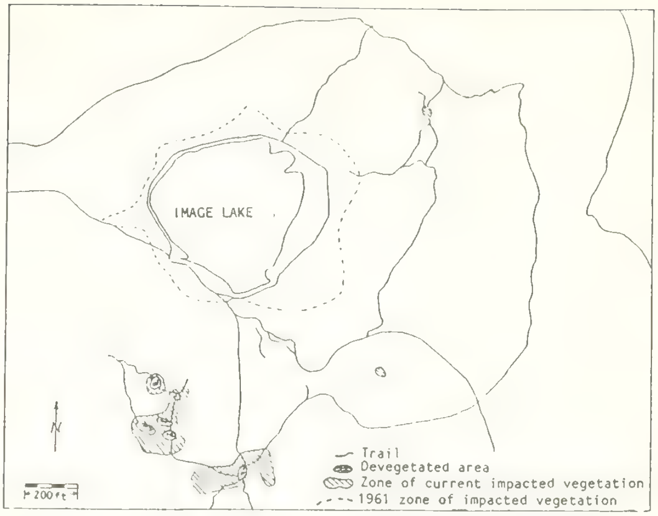

Figure 5.--Active trails, devegetated areas and zones of impacted vegetation found in 1984 at Image Lake, Glacier Peak Wilderness.

scenic focal point of Image Lake. Almost all the new impact has been relegated to a non-focal point area that is not visible to wilderness users that visit Image Lake.

This system of establishing "Designated Campsites" away from key focal points has been successfully used throughout the North Cascades National Park. At key focal points such as Cascade Pass, Whatcom Pass, Easy Pass and Park Creek Pass, impact has been greatly reduced except at the immediate crest of the pass. At these immediate focal points, impact is continuing to increase, but is restricted to a relatively small area. In contrast, the manager located "Designated Campsites" are being heavily impacted, with most of the campsites completely void of vegetation. These areas are not at scenic focal points and are usually not visible to the wilderness traveler.

EDUCATION - MINIMUM IMPACT CAMPING SYSTEM

Another common wilderness management system is to educate the wilderness user about minimum impact camping and to install attitudes and camping behavior that will reduce impact on the vegetation. At the present time in the North Cascades National Park, wilderness users are given an alternative to camping in the heavily impacted "Designated Campsites". They may obtain a cross country permit if they agree to camp at least one mile from a trail and to practice "Minimum Impact" camping.

A limited study was conducted in the North Cascades Mtns. which included the North Cascades National Park, Glacier Peak Wilderness area and the Pasayten Wilderness area. This study was conducted over a two year period to determine the effect of this type of limited education system. Cross country backpacking parties that were at least one day's hike from a trail were contacted and indirectly interviewed about their knowledge and attitudes toward "Minimum Impact" camping. When possible,

a photograph was taken of their campsites before it was well established, and/or the general condition of the vegetation was noted. The condition of their campsite after being vacated the next day was recorded and compared to the site before it was established. The results of this study indicated that although 100% of users were aware of minimum impact camping, 18 out of the 20 parties interviewed caused what appeared to be severe impact to previously untrammeled vegetation or to vegetation in lightly used campsites. Another study conducted by Boag (1976) in the Trinity Alps and Marble Mts. Wilderness Areas of Northern California involved the interviewing of a total of 376 people in 94 groups. Each group had received a wilderness permit and information about minimum impact camping and all were concerned about wilderness preservation. Based upon follow-up observations, ninety-two percent of these groups did not practice minimum impact camping even though they were aware and concerned about it.

The conclusion, based upon these two studies, is that a limited education program about minimum impact camping does not reduce impact on vegetation in wilderness areas.

VEGETATION RECOVERY RATES

Many of the permanent plots at Image Lake and other areas have been free of any noticeable recreational impact since 1966 and can be monitored to determine the recovery rates of the vegetation. The results of this monitoring to date show that vegetation recovery rates following cessation of trampling or camping impact are quite variable throughout the study areas.

Natural recovery rates in Carex dominated vegetation types have been fairly rapid. Over a 4 year period at Whatcom Pass the percent cover increased almost 40% from an average of 23% to 31% on heavily used sites. At Image Lake, cover on some Carex vegetation types more than doubled increasing from an average of 40% to 100% over a 12 year period. At Park Creek Pass, moderately trampled Carex meadows recovered over a 12 year period from an average percent cover of 67% to an average percent cover of 92%.

The recovery rates in the Phyllodoce/Vaccinium vegetation type have been slower. At Whatcom Pass, even without continued trampling the percent of cover decreased from 54% to 51% over a four year period. At Park Creek Pass on nine moderately trampled campsites the vegetation increased 50% from an average of 46% to 78%. At Image Lake the vegetation cover on 12 moderately used campsites increased by two thirds from an average cover of 37% to 62% over a 13 year period of non-use. The main plants that increased in coverage on these campsites are in order of abundance, Polygonum bistortoides, Penstemon procerus, Carex spp., Luetkea pectinata, Vaccinium deliciosum, Potentilla flabellifolia, and Erigeron peregrinus.

The recovery rates were fairly rapid in the Valeriana/Veratrum vegetation types at Image Lake. On 20 permanent plots located in lightly trampled vegetation the percent of vegetation cover increased over a 13 year period from 75 to 93%, while in 37 plots in moderately trampled vegetation the percent cover increased from 58 to 96%. The plants that increased or invaded in these plots were Anemone occidentalis, Valeriana sitchensis, Veratrum viride, Aster foliaceus, Polygonum bistortoides, Gentiona calycosa, Lupinus latifolius, Phlox diffusa and Pedicularis bracteosa. On six completely devegetated campsites in these vegetation types, over a 13 year period the average percent ground cover increased from 0 to 42% with the following plants being the main invaders: Phlox diffusa, Potentilla flabellifolia, Polygonum bistortoides, Hieracium gracile, Carex spectabilis, Antennaria lanata, Pedicularis bracteosa, and Erigeron peregrinus.

CONCLUSIONS

The wilderness management system used by managers in the North Cascades of Washington that successfully controls the amount of impact on vegetation and total devegetation is the manager selected "Designated Campsite" system. This system controls the location and area of impacted vegetation and prevents most impact from occurring at the scenic focal points. The other commonly used systems, "No Management", "100 Foot No Camping Limit", and "Education About Minimum Impact Camping" do not control the amount and area of impact and tend to allow heavy impact at the scenic focal points where it greatly reduces the wilderness experience.

The "No Management System" and "100 Foot No Camping Limit" are still the prevailing systems used in most of the wilderness areas of the North Cascades and of Northern California. The newly created wilderness areas in Northern California, (Siskiyou, Red Buttes and Russian) which have been unmanaged roadless areas, will be managed under the "No Management" system. Serious deterioration at the focal points in these areas has already occurred. Based upon the results of this study, continued management of most wilderness areas under these ineffective wilderness management systems predictably will subject them to additional impacts and will leave them more impaired for future wilderness users than they are now.

REFERENCES

Boag, Alistair J. The relationship of management and education in the recreational use and preservation of the wilderness environment. M.S. Thesis. Arcata, CA: Humboldt State University; 1976. 175 p.

Crowder, D.F.; Tabor, R.W. Routes and Rocks. The Mountaineers. Seattle, WA; 1965. 235 p.

DeWitz, Robert J. Personal communication. Bellingham, WA: U.S. Department of Agriculture, Forest Service, Mt. Baker National Forest; 1966 November 1.

Marshall, Louise B. 100 hikes in western Washington. The Mountaineers. Seattle, WA: 1966. 227 p.

Thornburgh, Dale A. An ecological study of the effect of man's recreational use at two subalpine sites in Western Washington. M.S. Thesis. Berkeley, CA: University of California; 1962. 51 p.

Thornburgh, Dale A. Campsite impact survey of the heavily used lakes in the Marble Mountains. Arcata, CA: Humboldt State University, FOR 136 class; 1975. 16 p. Unpublished report on file.

EXOTIC VEGETATION IN WILDERNESS AREAS

Jeffrey L. Marion, David N. Cole, and Susan P. Bratton

ABSTRACT: Exotic plant species have been introduced and dispersed throughout most, if not all, of our wilderness areas. Although most of these species are restricted to disturbed areas, some have become naturalized and are capable of invading and displacing native vegetation. This paper examines the reasons why wilderness managers should be concerned about these exotic species, their introduction and dispersal mechanisms, extent of occurrence, implications for managers, and potential methods for control.

INTRODUCTION

A pristine wilderness has value as both a recreational and scientific resource. Increasing numbers of recreationists are attracted to our wilderness areas largely because of their undeveloped and natural environments. Information about naturally functioning ecosystems from these undisturbed environments is becoming increasingly valuable as baseline data for the identification and evaluation of human-induced changes in developed environments. The values our society attaches to wilderness areas are directly tied to the present and continued purity of their natural ecosystems.

This paper examines one potential threat to the purity of wilderness ecosystems: the introduction and spread of exotic plant species. Plant species that are exotic for a particular area are those not indigenous to the area that have been either intentionally or unintentionally introduced.

These exotic plant species should be of concern to wilderness managers for three primary reasons. First, because they are not indigenous, exotic plants represent deviations from natural conditions. The Wilderness Act directs wilderness managers to maintain the "primeval character and influence" of these environments and to "preserve (their) natural conditions." Managers are therefore responsible for the protection of native biota and the preservation of functioning natural ecosystems.

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A second reason for concern about exotics is that their presence, particularly on disturbed recreation sites, provides the visitor with a false image of the area's natural vegetation. Most wilderness visitors would not recognize an exotic plant as being nonindigenous to a given area unless it was a highly publicized species, such as kudzu (Pueraria lobata) in the Southeast. However, wilderness visitors spend the majority of their time on trails and campsites where these species are prevalent. A visitor's perceptions of wilderness environments and vegetation are therefore influenced by the dominant plants on these recreation sites. Exotic species such as dandelions (Taraxacum officinale), plantain (Plantago spp.), and clover (Trifolium spp.), that are common both on campsites and in suburban lawns, might lead visitors to think that wilderness vegetation is little different from that in their own backyards.

A third cause for concern is that exotic plants may invade and displace native plant species. This could alter many natural processes, including plant succession and system productivity, diversity, and stability. Previous research has shown that exotic species have displaced native plants on many wildland recreation sites and grazed meadows, but for the most part are restricted to these areas. In the West, grazing pressure on native plants often promotes the invasion of exotic plant species. Even following the removal of grazing pressures, these species can continue to survive and reproduce, permanently altering the ability of an area to return to its original state. Similarly, disturbance-associated exotics can still be found on many prewilderness resort sites, home sites, and logging camps in the Boundary Waters Canoe Area Wilderness (BWCA) of Minnesota even though they have received no disturbance following site restoration work in the 1960's (Ahlgren and Ahlgren 1984).

In a BWCA campsite recovery study, sites closed 12 to 14 years exhibited significant differences in vegetative composition when compared to adjacent undisturbed areas (Marion 1984). Exotic species accounted for an average of 20 percent of the cover on these sites, but were not observed to be spreading into undisturbed vegetation. Six of the eight closed sites had developed extensive graminoid cover, which prohibited reinvasion by forest herbaceous species.

Exotic species which are not disturbance-associated are cause for even greater concern. In the BWCA, Ahlgren and Ahlgren (1984) found one aggressive exotic species, goutweed (Aegopodium

podagraria), once planted on a resort site, that had naturalized and spread vigorously since the lodge closed in 1955. This species has unique characteristics that enable it to outcompete native vegetation in undisturbed areas (Ahlgren and Ahlgren 1984):

> Very few herbs or shrubs grow in association with goutweed because it produces substances toxic (allelopathic) to many native species that would otherwise be found here. The plant grows well in sun or shade , and its carpet now extends six hundred feet along the shore and four hundred feet back into the woods behind the lodge site, eliminating native plants as it spreads. A taller, aggressive form with no color variegation on the leaves has appeared in shadier spots. It is spreading even more vigorously, giving good indications that it is a truly naturalized part of the flora.

In the Southwest, Cole (1985) reported that one exotic grass (Bromus rubens) "covers more ground, even on undisturbed sites, than any other species--probably in the entire Grand Canyon." In eastern National Parks, Butler and others (1981), Baron and others (1979), Bratton and Butler (1982), and Rosen and others (1982) repeatedly found Japanese honeysuckle (Lonicera japonica) and kudzu (Pueraria lobata) to be widespread and potentially threatening to native vegetation. These species are poor invaders of unlogged forest, however, and generally require further human disturbance to invade mature stands.

Other well-known examples of naturalized "problem" species are: purple loostrife (Lythrum salicaria), tamarisk (Tamarix spp.), cajeput tree (Melaleuca quinquenervia), Australian pine (Casuarina equisetifolia), and peppertree (Schinus terebinthifolius). Species such as these are capable of outcompeting and replacing native plants over large areas and thus pose a significant threat to natural wilderness plant communities. If these species become dominant, they are capable of altering succession and exerting far-reaching changes in plant and animal interrelationships in the wilderness ecosystem. Both scientific and esthetic values of wilderness areas would be severely compromised by the widespread presence of exotic plant species.

The introduction and dispersal of exotic plant species in wilderness areas, extent of plant occurrence, important management implications, and possible control methods are discussed in the following sections. A review of the literature and recent wilderness and backcountry studies from the West, Midwest, and East are used to illustrate these topics and the current status of exotic plant species in our wildland environments.

INTRODUCTION AND DISPERSAL MECHANISMS

Exotic plants have been introduced to wilderness areas in many ways. Many exotics were introduced and became well-established prior to wilderness designation. Plantain, a common exotic from Europe, was called "white man's foot" by Indians who noticed that it seemed to appear wherever the newcomers walked (Ahlgren and Ahlgren 1984). This is just one of the many weedy exotics that were unintentionally introduced by settlers and early homesteaders. Other exotics, such as shade and fruit trees, ornamental shrubs, and flowers, were planted intentionally around homesites and resorts in wilderness areas prior to wilderness designation. In most instances, these exotic plant species were not removed or destroyed when the buildings were later removed. In some instances, early wilderness managers introduced exotics during rehabilitation efforts through the use of popular ground cover seed mixes containing exotics or impure native seed mixes (Smith 1982; Stephenson and others 1980).

Pack and saddle stock are an important source of exotics in many wilderness areas. Seeds from exotic species that grow on farms and ranches are transported into wilderness areas in hay used for supplemental pack stock feed. Seeds of plants consumed by pack stock prior to entry into a wilderness area may also germinate following excretion within the wilderness area. Another source is the wilderness visitor, who unintentionally transports exotics into the wilderness in soil on boots and in equipment. Wind, water, and native birds and animals are also capable of introducing exotics.

A variety of dispersal mechanisms distribute exotic plant species once they are established in a wilderness. Seeds are easily transported along trails and between campsites by visitors and pack stock. For example, herbaceous plant seeds can readily adhere to damp tent bottoms or tarps and are transported from one camp to the next before falling off and germinating. Some seeds have hooked appendages that catch on clothing until they are brushed off. The ease of dispersal associated with use of horses is readily apparent in areas receiving heavy horse use, such as the Bob Marshall Wilderness in Montana. Highly distinct zones of exotic vegetation parallel extensive sections of trail in this wilderness. Natural methods of seed dispersal may also be important, particularly in distributing seeds to naturally disturbed locations in the wilderness.

EXTENT OF OCCURRENCE

Exotic plant species appear to be present in most, if not all, wildlands in the United States. Furthermore, exotic vegetation is often geographically widespread within these areas, although largely restricted to areas of human and natural disturbance. Reported findings of exotic vegetation in both Wilderness and National Park backcountry areas are presented below.

Studies of campsite impacts provide the majority of information concerning exotic vegetation in Wilderness areas. In the West, Cole (1977) found 27 species of exotics on campsites in the Eagle Cap Wilderness of Northeastern Oregon. Although restricted primarily to campsites, trails and

grazed meadows, exotics were widespread at elevations below 7,000 feet. However, only three exotic species were found on campsites--and they were not common--at higher elevations (Cole 1982). Since dispersal is not a problem, this suggests that exotics are poorly adapted to subalpine and alpine environments. In the Bob Marshall Wilderness of Montana, 27 exotic species were identified on campsites (Cole 1983). Large numbers of exotic species were also noted along trails and in grazed meadows throughout the wilderness.

In the Midwest, Marion (1984) found 22 exotic species on campsites in the BWCA. Nearly two-thirds of the 96 campsites studied had at least one exotic species present. However, Ahlgren and Ahlgren (1984), long-time botanists of the region, report that 92 species, over 11 percent of the 817 known BWCA flowering plant species, have been introduced. Twenty-three plant families and 70 genera are represented by the exotic species, 84 of which originated from Europe. Clearly, studies of a sample of campsites fail to pick up a large proportion of the exotic species present in a given area.

In the Southeast, White (1982) found 288 (20 percent) of the vascular plant species in the Great Smoky Mountains National Park (GSMNP) were exotics. Most of these species were confined to old home sites, lawns, and roadsides, but a few, such as Japanese honeysuckle, were displacing native understory species. Lindsay (1978) found 3.2 percent exotics on high elevation burn scars and up to 15.1 percent exotics on grassy balds (open mountain meadow communities) in GSMNP. In the backcountry of the park, exotics on campsites vary from 0 percent of the flora on sites with little disturbance to 30 percent around highly disturbed shelter sites.

Some ecosystems and climatic zones are more susceptable to exotic invasion than others. Oceanic islands are very vulnerable. Temperate and some high elevation grasslands are easily invaded by exotic forbs and grasses, many of which are preadapted to grassland habitats with short disturbance rotations. The native meadows in National Parks such as Yosemite are, in many cases, now dominated by exotic species. Exotics may establish quickly on geologically unstable sites, such as river banks, gravel bars, and barrier islands. Tamarix spp. have, for example, successfully occupied both the banks of the Colorado in Grand Canyon National Park and the banks of the Rio Grande in Big Bend National Park. On the other hand, some extreme environments, such as far northern and tundra sites, support few exotics. Undisturbed temperate deciduous forest and tropical rain forest are resistant to invasion due to vigorous competition from native species.

The method and frequency of human-related introductions also influence the number of exotic invaders. In the Bob Marshall Wilderness of Montana, Cole (1983) found campsites utilized primarily by backpackers to have relatively few exotic species with little relative cover (5 percent) when compared to campsites utilized by private and commercial horse parties, which had larger numbers of exotics with extensive relative cover (43 and 61 percent, respectively). In the BWCA, campsite history was found to be an important factor influencing the number of exotics on campsites (Marion 1984). For example, 57 percent of campsites established in previously natural undisturbed vegetation had exotic species, with an average of 1.9 exotics per site. In comparison, all of the campsites established on former resort sites had exotic species present, with an average of 5.3 exotics per site. The campsite with the largest number of exotics (12) had been established on an old logging camp. These camps employed horses and oxen, and many of the exotics commonly associated with the hay brought in to feed these animals (including many grass and clover species) are still present, even in currently undisturbed areas.

A list of exotic plants found in these and other studies of wildland recreation sites in the United States is presented in table 1. A significant number of these species are found in more than one area, indicating not only their widespread occurrence, but that relatively few herbaceous species possess the morphological and life-history characteristics necessary for survival in highly disturbed environments.

MANAGEMENT IMPLICATIONS

Although exotic species are already present in most, if not all, wilderness areas, there are steps that managers can take to minimize future introductions, and to control, reduce, and possibly eliminate exotics currently in an area. The first step in an exotic species management program is to conduct a comprehensive inventory within an area to identify the exotic species present, including their distribution, frequency, and cover.

Representative specimens should be collected for each exotic species and a botanical biography, including each plant's identifying characteristics, requirements, phenology, and reproductive methods, should be developed.

The second step is to group exotics on the basis of extent of occurrence, relationship to disturbance, and ability to threaten undisturbed vegetation. Proposed groupings for management are:

1. Common disturbance-associated species -- exotics with ruderal characteristics that are common on and restricted to campsites, trails, and grazed meadows.

2. Uncommon relict species -- exotics that were intentionally planted around homesites and resorts prior to wilderness designation and were not removed during site restoration work or rare species only established in a few places.

3. Competitive "pest" species -- exotics that are able to displace native undisturbed vegetation.

Table 1.--Herbaceous exotic plant species reported on wildland recreation sites

SPECIES	CITATION
Achillea millefolium	Marion (1984); Lindsay (1978)
Agropyron repens	Cole (1983); Marion (1984)
Agrostis alba	Cole (1977,1983); Marion (1984); Lindsay (1978)
Arabis glabra	Cole (1983)
Arenaria serpyllifolia	Cole (1977)
Artemesia vulgarus	Cole (1977)
Bromus brizaeformis	Cole (1977)
Bromus inermis	Cole (1983); Marion (1984)
Bromus rubens	Cole (1985)
Bromus tectorum	Cole (1977,1983,1985)
Capsella bursa-pastoris	Cole (1977,1983); Marion (1984)
Cerastium vulgatum	Marion (1984)
Cichorium intybus	Lindsay (1978)
Chenopodium album	Cole (1983); Marion (1984)
Cirsium arvense	Cole (1977); Marion (1984)
Cirsium vulgare	Cole (1977)
Chrysanthemum leucanthemum	Marion (1984); Lindsay (1978)
Cynoglossum officinale	Cole (1977)
Dactylis glomerata	Sutton (1976); Cole (1977,1983); Lindsay (1978)
Daucus carota	Lindsay (1978)
Erodium cicutarium	Cole (1985)
Festuca rubra	Marion (1984)
Filago arvensis	Cole (1983)
Galinsoga ciliata	Lindsay (1978)
Hieracium aurantiacum	Marion (1984)
Holcus lanatus	Lindsay (1978)
Hordeum leporinum	Cole (1985)
Hypericum perforatum	Cole (1977)
Lactuca serriola	Cole (1977)
Lappula echinata	Cole (1977)
Lepidium virginicum	Cole (1977)
Lychnis alba	Cole (1983)
Matricaria matricarioides	Cole (1983); Marion (1984)
Medicago lupulina	Cole (1977,1983)
Phleum pratense	Cole (1977,1983); Marion (1984); Lindsay (1978)
Plantago lanceolata	Sutton (1976); Saunders (1979); Ranz (1979); Lindsay (1978)
Plantago major	Cole (1977,1983); Ranz (1979); Fichtler (1980); Marion (1984); Lindsay (1978)
Poa annua	Ranz (1979); Fichtler (1980); Cole (1982,1983); Saunders (1979); Lindsay (1978)
Poa palustris	Cole (1983); Marion (1984)
Poa pratensis	Dale and Weaver (1974); Sutton (1976); Cole (1977,1983); Saunders (1979); Fichtler (1980); Marion (1984)
Polygonum aviculare	Cole (1983); Marion (1984)
Polygonum cilinose	Saunders (1979)
Potentilla argentea	Cole (1983)
Prunella vulgaris	Sutton (1976); Marion (1984); Lindsay (1978)
Ranunculus acris	Saunders (1979); Marion (1984)
Rumex acetosella	Cole (1977,1983); Ranz (1979); Lindsay (1978)
Rumex crispus	Cole (1983)
Rumex obtusifolius	Lindsay (1978)
Sisymbrium altissimum	Cole (1977)
Spergularia rubra	Ranz (1979); Cole (1982)
Taraxacum officinale	Cole (1977,1983); Saunders (1979); Ranz (1979); Fichtler (1980); Marion (1984); Lindsay (1978)
Thlaspi arvense	Cole (1977,1983)
Tragopogon dubius	Cole (1977,1983,1985)
Trifolium pratense	Sutton (1976); Cole (1977,1983); Marion (1984); Lindsay (1978)
Trifolium procumbens	Marion (1984)
Trifolium repens	Dale and Weaver (1974); Sutton (1976); Cole (1977,1983); Ranz (1979); Saunders (1979); Marion (1984); Lindsay (1978)
Verbascum thapsus	Cole (1977,1983)
Veronica serpyllifolia	Marion (1984)

The third step is to formulate management policies that will minimize the introduction of exotics. For example, managers may require horse users to carry only pelletized feed instead of hay. Seed used in restoration or rehabilitation work should be of native species and pure (purchased seed typically contains a small percentage of extraneous seeds from other species). A number of specialized seed companies can supply pure seed for a wide variety of native species.

The fourth step is to formulate management policies for the control of exotics presently in an area. Because most exotics are restricted to disturbed areas, managers should try to minimize the amount of disturbed land within wilderness boundaries. In GSMNP, for example, canopy opening, due either to park maintenance practices or to visitor trampling, has encouraged exotic establishment. Further, Bratton and others (1978) and Bratton and others (1982) have shown that the amount of visitation is correlated to disturbance of campsite understories and to reduction in basal area of the canopy. Site management that reduces the destruction of canopy and of leaf litter will thus tend to discourage exotic invasion. As discussed by Cole (1981), visitor dispersal strategies tend to increase the total area of disturbance; visitor concentration strategies may need to be encouraged. Managers should also try to minimize the amount of grazing by horses, perhaps through regulations requiring the carrying of pelletized feed.

Management actions involving the removal of exotics should be related to groupings of exotics such as those proposed above. Common disturbance-associated species, which are typically not a threat to undisturbed vegetation, are almost inevitable on recreation sites. Managers can reduce or minimize the spread of these exotics, particularly through the minimization of human-related vegetation disturbance. However, DeVos and Bailey (1970) noted that, to some extent, the presence of these disturbance-associated exotics is fortuitous, as they partially protect the soil from erosion as well as contribute some organic matter that helps maintain the soil structure.

Uncommon relict species, such as shade trees, ornamental shrubs, and garden flowers, are found in areas of past disturbance and can occasionally be a threat to undisturbed vegetation. These species should generally be removed whenever encountered, but in most instances natural successional processes will eliminate them over time. Few of these exotics are strong competitors under closed canopies.

Competitive "pest" species that have the potential to invade and replace native undisturbed vegetation are of the greatest concern for managers. Control of these species will require active management programs. Complete elimination of these species is often not possible or cost-efficient.

Development of an effective and efficient exotic control program involves careful evaluation of both the exotic species of concern and the range of potential control methods. Information concerning exotic species and control methods can be obtained from universities and colleges, federal, state, and county agricultural departments, the U.S. Forest Service, National Park Service, and other federal agencies. Libraries are another excellent source of information and in particular, a quarterly publication known as the Natural Areas Journal provides a continuing source of information regarding the control of exotic "pest" species.

METHODS OF CONTROL

A variety of methods, including the application of herbicides, prescribed burning, mowing, bulldozing, hand digging, cutting, and biological control may be used to kill or remove existing exotic vegetation. Research has indicated that herbicides, in many instances, will offer the most efficient form of control but may have detrimental impacts on wilderness environments. Their use should be carefully evaluated before application. Important considerations include:

1. Effectiveness against target species. Some herbicides kill grasses but have little impact on forbs. Others kill broad-leafed species but are less effective on conifers.

2. Optimal strategies of application. Some herbicides are more effective early in the growing season; others may be more effective late in the season when plants are translocating starch to the roots. Application more than once a year is frequently necessary, particularly on woody plants that are likely to resprout. Too little or too much herbicide may be used, especially by inexperienced applicators. Too much of some sprays, for example, will top-kill the plant without allowing time for the toxin to translocate to the roots.

3. Half-life of the herbicide and decomposition by products. Some herbicides remain in soil and water much longer than others. Some compounds break down into inorganic substances; others may produce potentially toxic compounds.

4. Possible impacts on nontarget species. Some herbicides are very general and will kill any vascular plant. Some compounds present more danger to animals than others, and some may be carcinogenic.

5. Method of application. Injection, for example, allows the herbicide to be applied to individual woody plants, whereas broadcast spraying may result in problems with drift to nontarget species. Rosen (1982) used preliminary broadcast spraying of large areas of kudzu. After a majority of the plants had died he used a very fine nozzle to apply herbicide to individual remaining kudzu plants.

6. Use of the site for scientific studies. In some cases, local contamination with pesticides may be undesirable because the site is being used for pollution monitoring or other research. This is true of some National Park wilderness watersheds.

Many effective control programs use more than one control technique or carefully timed applications of the same technique. Most woody exotics root- or stump-sprout and may need treatment more than once a growing season. Fire may be very effective for initial suppression of exotics, but often needs to be followed by cutting, mowing, or herbicides. Timing of these treatments can be very critical. A spring burn may help reduce exotic populations, whereas a fall burn does not, or vice versa. The intensity of the fire may also determine the success of the effort. A fire that is too cool may not remove the target species; a fire that is too hot may eliminate native vegetation and leave the site prone to further exotic invasion. Alternative methods, such as pulling, digging, and cutting by hand, are labor intensive. These methods are seldom 100 percent effective, particularly with species that easily resprout (Stephenson and others 1980).

Preventative measures may in the case of some types of exotic plants be the only realistic management. Many exotic herbs, for example, will reinvade disturbed areas following removal efforts and will continue to outcompete native species on badly trampled sites. It is therefore extremely important to encourage the reestablishment of native vegetation. This may be done by protection. A campsite may be closed to reduce trampling and allow reestablishment of native species after exotics are removed. In severely disturbed areas, or those previously dominated by exotics, planting may be used to speed succession, to prevent soil erosion, and to change local environmental conditions. Rosen (1982), for example, tested planting of both deciduous and coniferous tree seedlings, after initial herbicide treatment, on sites occupied by kudzu. Although drift killed some seedlings, most survived the later herbicide treatments directed at individual kudzu crowns.

Exotic plant management programs cannot be one-shot efforts. To be successful, these programs must be long-term, incorporating control efforts into routine resource management efforts. A monitoring program to evaluate the ongoing status of exotic vegetation is vital to successful control. Periodically, a reassessment of the type, number, location, and distribution of "pest" exotic species should be made. Information collected could also be used to evaluate the success of control measures and removal techniques.

REFERENCES

Ahlgren, Clifford; Ahlgren, Isabel. Lob trees in the Wilderness. Minneapolis, MN: University of Minnesota Press; 1984. 207p.

Baron, Jill; Dombrowski, Christine; Bratton, Susan P. The status of five exotic woody plants in the Tennessee District of Great Smoky Mountains National Park. In: Proceedings, 1st conference on scientific research in the National Parks; 1976 November 9-12; New Orleans, LA. Transactions and Proceedings Series No. 5. Washington, DC: U.S. Department of Interior, National Park Service; 1979: 101-105.

Bratton, S. P.; Hickler, M. G.; Graves, J. H. Visitor impact on backcountry campsites in the Great Smoky Mountains. Environmental Management. 5(2):431-442; 1978.

Bratton, S. P.; Stromberg, L.; Harmon, M. E. Firewood-gathering impacts in backcountry campsites in Great Smoky Mountains National Park. Environmental Management. 6(1):63-67; 1980.

Bratton, S. P.; Butler, T. The distribution of exotic plant species at Cowpens National Battlefield. Report for the Superintendent. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Regional Office; 1982. 18p.

Butler, Teri; Stratton, Donald; Bratton, Susan. The distribution of exotic woody plants at Cumberland Gap National Historic Park. NPS-SER Research/Resources Management Report No. 52. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Regional Office; 1981. 34p.

Cole, David N. Man's impact on wilderness vegetation: an example from Eagle Cap Wilderness, northeastern Oregon. Eugene, OR: University of Oregon; 1977. 307p. Dissertation.

Cole, David N. Managing ecological impacts at wilderness campsites: an evaluation of techniques. Journal of Forestry. 79(2):86-89; 1981.

Cole, David N. Wilderness campsite impacts: effect of amount of use. Research Paper INT-287. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 34p.

Cole, David N. Campsite condition in the Bob Marshall Wilderness, Montana. Research Paper INT-312. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 18p.

Cole, David N. Ecological impacts on backcountry campsites in Grand Canyon National Park. Unpublished report. Grand Canyon National Park, AZ: U.S. Department of the Interior, National Park Service; 1985. 96p.

Dale, D.; Weaver, T. Trampling effect on vegetation of trail corridors of North Rocky Mountain forests. Journal of Applied Ecology. 11:767-772; 1974.

DeVos, A.; Bailey, R. H. The effect of logging and intensive camping on vegetation in Riding Mountain National Park. Forestry Chronical. 46:49-55; 1970.

Fichtler, R. K. The relationship of recreational impacts on backcountry campsites to selected Montana habitat types. Missoula, MT: University of Montana; 1980. 109p. Thesis.

Lindsay, M. The vegetation of the grassy balds and other high elevation disturbed areas in the Great Smoky Mountains National Park. NPS-SER Research/Resources Management Report No. 26. Atlanta, GA: U.S. Department of the Interior, National Park Service; Southeast Regional Office; 1978. 150p.

Marion, Jeff L. Ecological changes resulting from recreational use: a study of backcountry campsites in the Boundary Waters Canoe Area Wilderness, Minnesota. St. Paul, MN: University of Minnesota; 1984. 279p. Dissertation.

Ranz, Beth. Closing wilderness campsites: visitor use problems and ecological recovery in the Selway-Bitterroot Wilderness, Montana. Missoula, MT: University of Montana; 1979. 125p. Thesis.

Rosen, Aaron; Owen, India; Bratton, Susan P. Exotic plant survey of the Lookout Mountain Unit at Chickamauga and Chattanooga National Military Park. Report for the Superintendent. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Regional Office; 1982. 14p.

Rosen, Aaron. Feasibility study: Eradication of kudzu with herbicides and revegetation with native tree species in two national parks. NPS-SER Research/Resources Management Report No. 59. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Regional Office; 1982. 59p.

Saunders, Paul R. The vegetational impact of human disturbance on the spruce-fir forests of the southern Appalachian Mountains. Durham, NC: Duke University; 1979. 177p. Dissertation.

Smith, Paul. [Personal communication.] Ely, MN: U.S. Department of Agriculture, Forest Service, Superior National Forest; 1982.

Stephenson, W. R.; Dowhan, R.; Stranak, M. Removing exotic vegetation from Point Pelee National Park. Parks. 5(3):12-16; 1980.

Sutton, S. W. The impact of floaters on the Ozark National National Scenic Riverways. Columbia, MO: University of Missouri; 1976. 152p. Thesis.

White, P. S. The flora of the Great Smoky Mountains National Park: an annotated checklist of the vascular plants and a review of previous floristic work. NPS-SER Research/Resources Management Report No. 55. Atlanta, GA: U.S. Department of the Interior National Park Service, Southeast Regional Office; 1982. 219p.

PENETRATION OF THE CAIRNGORMS MOUNTAINS, SCOTLAND, BY VEHICLE TRACKS AND FOOTPATHS: IMPACTS AND RECOVERY

Neil G. Bayfield

ABSTRACT: Vehicle tracks and footpaths have greatly increased in number since about 1960. Most wilderness users think tracks damage remoteness quality, but are less critical of footpaths. Tracks are often badly built, but there have been few instances of serious erosion and spoil is gradually colonized by native species. New footpaths near Cairn Gorm ski area have deteriorated but older, traditional footpaths have shown less change, and two disused paths have partly recovered. Management of the Cairngorms area is divided between many different interests. An overall policy is needed to reduce the impact of both tracks and footpaths.

INTRODUCTION

This paper assesses the impact of vehicle tracks and footpaths on a Scottish wilderness area. The Cairngorms Mountains provide many contrasts with wilderness areas in North America. For instance, if "wilderness" is defined as ground more than 2 miles (3.2 km) from a public road, then the Cairngorms with about 500 sq. miles (1400 km^2) is one of the best examples in Britain, although small by North American or Scandinavian standards. The pattern of land tenure and land use is also quite distinct. Although parts of the area are used for skiing and other types of outdoor recreation, most of the area is privately owned and managed for game.

The vegetation of the Cairngorms is predominantly natural or semi-natural dwarf shrub heaths and montane heaths, but with a pronounced altitudinal sequence from *Calluna vulgaris* heath at low levels up to wind-blasted *Juncus trifidus* heath with 60% or more bare ground on summit plateaux (Watt and Jones 1948). Enclosed grazings and commercial woodland are largely confined to valleys and ground below 1600 ft (500 m) (fig. 1).

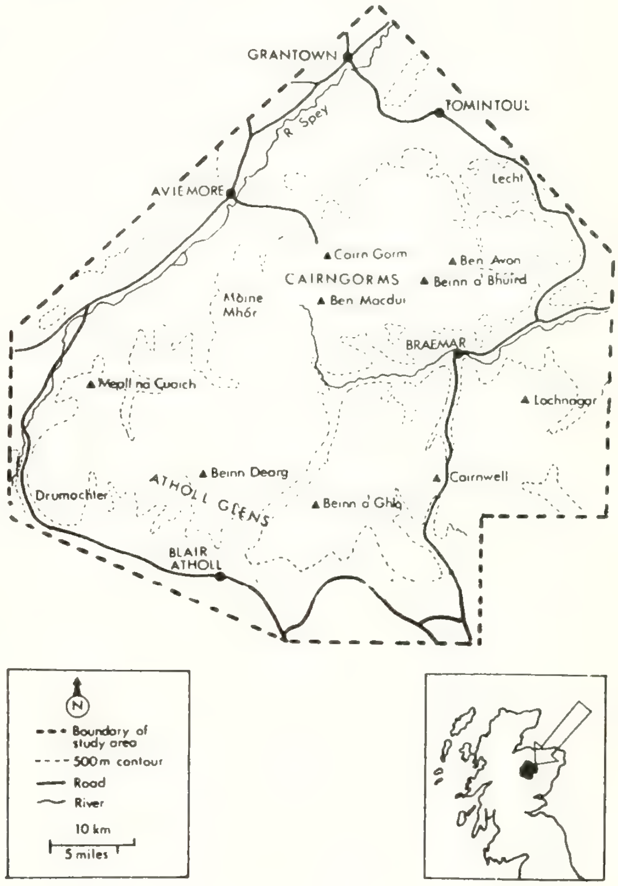

Figure 1.--Outline of the Cairngorms area. The boundaries of the area are similar to those used in the Scottish Development Department (1967) and Edinburgh University (1978) Cairngorms area studies.

Although there is hardly any intensive agriculture above 500 m, almost the whole area has been subjecte to felling, grazing, and burning pressures for centu ries, and hardly any natural treeline or montane scrub vegetation survives (Miller and Cummins 1982).

Some sheep grazing of unfenced hill ground occurs in parts of the Cairngorms, for example near the Cairnwell, Tomintoul, Drumochter, and Blair Atholl, but much larger areas are managed primarily for game. Grouse moors mainly below 1800 ft (550 m) are usually burnt in small patches on a 10-15 year cycle. The largely treeless red deer (*Cervus elephas*) "forests" cover a much wider altitudinal

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band (to the tops of the highest hills) and receive little formal management, apart from the culling of surplus animals and burning. The density of red deer is generally too high to permit tree regeneration except in fenced enclosures. It is to provide access to remote hills for shooting, that the many recent hill tracks have been bulldozed. These tracks are mostly on private land, and are not open to the general public in vehicles, although they can be used for walking and cycling.

Formal provision of facilities for outdoor recreation is mostly confined to the ski areas of Cairn Gorm, the Cairnwell and the Lecht, and to a small number of campsites, rights of way and nature trails. Walking and climbing take place throughout the area, but the largest numbers of visitors are in the vicinity of the two most accessible high peaks, Lochnagar and Cairn Gorm. Although there are few restrictions on pedestrian access in the Cairngorms, landowners discourage visitors during the shooting and stalking season (mainly August-October).

The climate of the Cairngorms is characteristically severe, with high winds and low average temperatures. Frost can be experienced in any month (Green 1974). Vegetation above about 2,500 ft (750 m) is generally prostrate, and plant cover may be discontinuous, particularly on ridges, because of wind-blast (Bayfield 1984).

Apart from the new tracks and ski areas, the general appearance of the Cairngorms is one of relatively undisturbed wild country. The vegetation looks fairly 'natural' and there are few artifacts. Many of the buildings and walls that occur above the valleys are ruinous relics of once higher numbers of people in the glens, and more extensive agriculture.

Paths and vehicular tracks are just two of the pressures that affect the wilderness value of the Cairngorms. How severe their effect is depends on the criteria and viewpoints applied. This paper uses contrasting perspectives to assess the significance of paths and tracks; and to compare them with other forms of landscape disturbance such as climate, grazing and burning.

A WALKER'S PERSPECTIVE

Vehicle tracks

Hill walkers generally have clear views about the importance of intactness and remoteness in wilderness areas. Aitken (1973), for example, interviewed 1000 outdoor people (members of walking clubs, services personnel and casual respondents) about wilderness values. 72% of those questioned thought vehicle tracks intrusive, and only 4% would have liked more tracks. However, 27% would have liked more paths, so that this type of access route was apparently not so disliked.

The walker reaching the summit of his chosen mountain can certainly lose some of the sense of achievement as well as the feeling of remoteness when he discovers a landrover approaching from the other side, up the raw scar of a bulldozed track. Such experiences have created a feeling of outrage among at least some outdoor people, and led to demands for curbs on further track construction (Curry-Lindahl and others 1982).

Tracks of various kinds are not, however, new to the Cairngorms. The traditional cattle-driving ("drove") routes were probably wide and badly worn when in use (mainly up to the middle of the last century). Victorian and early twentieth century estate roads were built by hand, with retaining, walls and culverts made of stone. Some may have been intrusive when newly built, but they were mainly low-level routes, not visible from a great distance.

Modern bulldozed tracks are much more visible, partly because their routes tend to climb above the valleys. Further, they are edged with untidy heaps of undressed spoil, with numerous exposed boulders. The pale granite gravel subsoil on many of the tracks tends to contrast strongly with the dark green and brown of the surrounding heath vegetation, and weathering to a more neutral hue takes several decades. As well as being visually intrusive human artifacts, tracks shrink the wilderness which they penetrate. The network of vehicle tracks has grown so considerably since 1960 that there are now only small areas more than 2 miles (3.2 km) from a track (fig. 2).

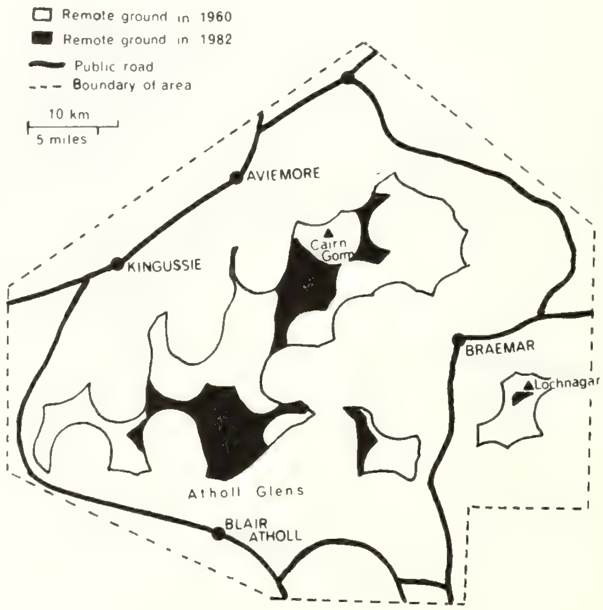

Figure 2.--Decreases in the areas of ground 2 miles (3.2 km) from vehicular tracks, 1960-1982. Only principal public roads are shown. After Watson (1984a).

There is now nowhere more than 4.5 miles (7 km) from a vehicle track (Watson 1984a).

Footpaths

Aitken's data suggest that walkers consider paths less intrusive than vehicle tracks. Footpaths can, of course, range from faint signs of wear to broad, rutted ribbons of bare ground. However, only a minority of walkers seem to criticise even badly worn routes. For example, Bayfield and Moyes (1972) interviewed 59 parties leaving a badly rutted peat path up Stac Polly (N W Scotland) in 1971. 90% considered the footpath in satisfactory condition, and only 32% would have liked to see any maintenance work done, such as drainage of wet sections or provision of steps at steep sections.

Although many walkers may not perceive footpaths as a serious intrusion into remote ground, there can be no doubt that there have been substantial increases in the numbers and extent of footpaths in recent years. Watson (1984b) found an increase of about 40 miles (64 km) in the block of mountains near the Cairn Gorm ski area, and smaller increases near popular mountains in the southeast of the Cairngorms Mountains. Bayfield (1985) looking mainly at the Cairn Gorm ski area found similar increases. Uplift to near the summit of Cairn Gorm has greatly increased the numbers of walkers visiting the adjacent, previously remote, Cairn Gorm-Ben Macdui plateau. Data from Anderson Semens Houston (1981) for fine summer days in 1980 indicate that nearly 800 people per day reached Cairn Gorm summit, and about 150 set off across the plateau towards Ben Macdui. For some outdoor people this relatively heavy traffic destroys remoteness value and they have to look elsewhere for the wilderness qualities that they seek. Such people are uncommon in interview surveys, but tend to be vociferous in defense of remoteness.

A LANDOWNER'S VIEW

It is difficult to manage a mountain estate profitably in Scotland, and vehicle tracks are seen as essential to improve the accessibility of remote ground. This is because nowadays shooting guests are reluctant to walk long distances across hill ground to get to their sport, and fewer estate staff are employed than formerly. Construction is not undertaken lightly, as costs are high, but because there are few constraints on siting and construction and no grant aid available, most tracks get built but not designed. Most landowners would probably like to improve standards but cannot afford the extra expense. It is only since 1980 that planning control has been applied to some categories of track, and only in National Scenic Areas (only a part of the Cairngorms area).

Naturally, because of the high capital costs of construction and maintenance, vehicle use of tracks is private. Public use would in any case require car parks, and a possibly substantial increase in disturbance of game.

AN AREAL PERSPECTIVE

The various pressures on the Cairngorms, including grazing, burning, recreation and climate, all disturb vegetation to a greater or lesser extent, and in places result in its local destruction. A survey of bare ground at 274 random points in the Cairngorms undertaken in 1981 (Bayfield, unpublished) provides a measure of the areal impact of different types of disturbance. The sample was structured by first classifying every kilometre square in the Cairngorms into one of eight land classes or groups by indicator species analysis of map characteristics (Bayfield and others 1982). A similar number of squares from each of the eight groups was selected at random, and four stratified random 239 sq yd (200 m^2) quadrats examined in each square. In each case, all bare ground present was measured using the step pointing technique (Cunningham 1975) and attributed to cause as far as possible.

The distinguishable causes of bare ground included wind blast, water erosion (including eroded peat areas), burning (areas burnt up to 5 years previously), animal paths, human footpaths, animal scrapes (including burrows), molehills, bulldozed vehicle tracks, and "other"causes (including unknown or uncertain causes, dung and carcases). The survey showed that burnt areas had, on average the most bare ground (28%) followed by wind blasted sites (20%), vehicle tracks and water erosion (10% each, although the figure for tracks was based on a single instance, so may be unrepresentative), human footpaths (5%), animal paths (2%) and scrapes and molehills ($<1\%$ each) (table 1).

A different pattern was shown by the frequency of occurrence of bare ground categories. Animal paths were the most frequent (in 29% of quadrats) followed by water erosion, wind blast, and animal scrapes (12-14% each). Burning occurred only in 8% of quadrats, and footpaths (4%) were less frequent than molehills (6%).

These data were extrapolated to the whole area using the proportions of kilometre squares in each of the eight land classes, and the frequencies of bare ground in each land class. Wind blast caused the largest total amount of bare ground (2.5%), followed by burning (2.1%), and water erosion (1.3%). Human footpaths caused 0.2%, only a third of the bare ground attributable to animal paths.

This analysis shows that although human footpaths cause fairly substantial amounts of bare ground where they occur, their frequency in the area as a whole is comparatively low, so that, overall, they result in much less bare ground than animal paths, burning or climatic disturbance. Vehicle tracks were so infrequently sampled as to have an almost negligible impact in terms of area.

Table 1.--Causes, areal extent and frequency of bare ground in the Cairngorms area. n = number of quadrats where each cause was recorded. Frequency data have been corrected to apply to the whole Cairngorms area, not just the stratified random sample

Cause	Average attributable cover of bare ground where present (%±SE)	n	Frequency of attributable bare ground in random quadrats (%)	Estimated bare ground cover in Cairngorms, by cause (%)
Burning	28.1 ± 7.1	11	7.6	2.1
Wind	20.0 ± 3.2	39	12.7	2.5
Vehicle tracks	10.0	1	0.8	0.08
Water	9.7 ± 2.6	49	13.6	1.3
Human footpaths	5.2 ± 1.5	13	4.2	0.2
Animal paths	2.1 ± 0.7	73	29.2	0.6
Animal scrapes	0.3 ± 0.2	41	12.3	0.04
Molehills	0.1 ± 0.02	17	6.4	0.06
"Other" causes	2.9 ± 0.9	59	27.6	0.8

ECOLOGICAL IMPACT OF TRACKS AND FOOTPATHS

Footpaths

The bare ground along human footpaths is usually semi-permanent, maintained by frequent disturbance. In this respect, human paths resemble areas of bare ground caused by wind blast, water erosion and animal paths, where re-vegetation is prevented by frequent disturbance. Some very wide footpaths have resulted in erosion and deposition of gravel on otherwise intact vegetation (Bayfield 1974) but such instances are uncommon. Mountain paths do not seem to impede the movement of animals; indeed many animals such as foxes often use human footpaths. Paths can certainly intercept the drainage of slopes they cross, and almost certainly modify the vegetation in consequence, but there has been little study of these effects. The principal impact of paths appears to be more visual than ecological. The serious deterioration in path condition recorded from the Cairngorms and other upland areas of Britain nevertheless gives cause for concern (Bayfield 1985). Examples of progressive widening of recent footpaths near Cairn Gorm are given in figure 3. It is, as yet, uncertain if the increasing deterioration is a response to increasing pressure, or if path widths take a number of years to stabilise. On the one hand, Aitken (1985) suggests, from the membership of climbing clubs and other statistics, that use is still rising. However, the use of the Chair-lift on Cairn Gorm in summer has tended to fall since 1970 (Anderson Semens Houston 1981), and counts bv Watson (pers. comm.) of walkers on the Cairn Gorm plateau suggest a possible decline in use since a peak in the middle of the last decade. Further regular surveys of visitor use would clarify a confused situation. In contrast to the pattern of expansion of recent footpaths, traditional routes like the Lairig Ghru have changed little in width (fig. 3) but again it is

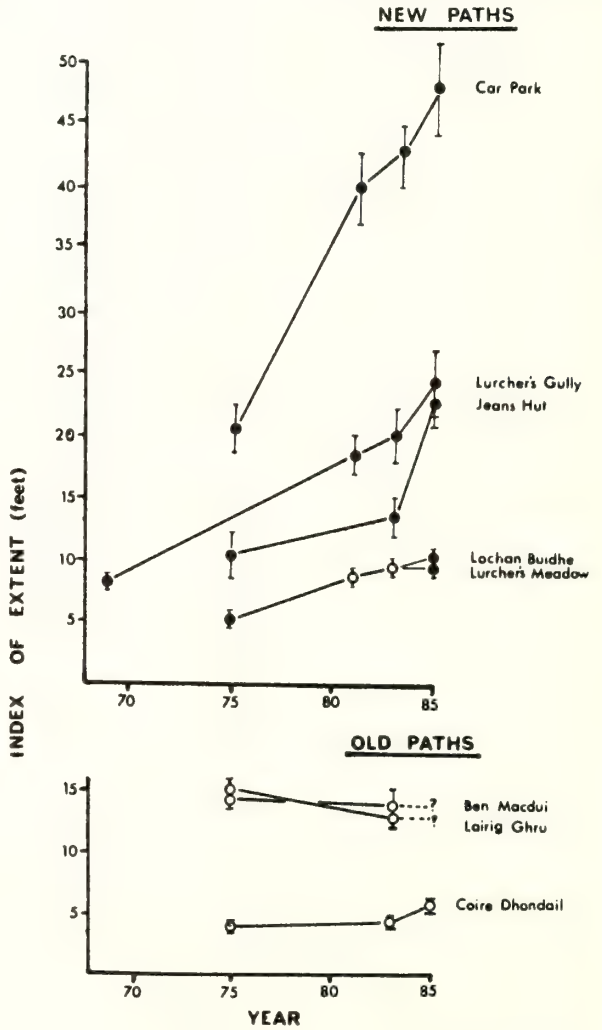

Figure 3.-- Changes in width ("index of extent" = total width + bare width) of a) 5 new paths near Cairn Gorm and b) 3 old, traditional paths through the Cairngorm mountains. (±SE)

not clear whether this is because the route is long established and relatively stable in width, or whether there has been little change in use relative to the more recent paths.

The extent of path deterioration depends on many factors, including levels of use, vegetation type and drainage. Deterioration on peat surfaces, for example, is particularly rapid, and leads not only to wide and rutted surfaces, but to the development of multiple paths. Where vegetation cover has been destroyed, spontaneous colonisation by native species does not usually occur, even if use falls or stops, because of frost heaving and crumbling of the exposed peat.

Paths on well drained mineral soils do not usually show as much wear as peat paths, for the same level of use (Countryside Commission 1973; Bryan 1977; Naylor 1977). Even high-altitude paths on mineral soil appear capable of being recolonised when use falls or ceases. The Sròn an Aonaich and Marquis Well paths on Cairn Gorm provide documented examples (fig. 4). Use fell on the Sròn an Aonaich path after 1960, and is now very low. Since being measured for the first time in 1975, width has steadily declined, and the ages of some of the colonising plants

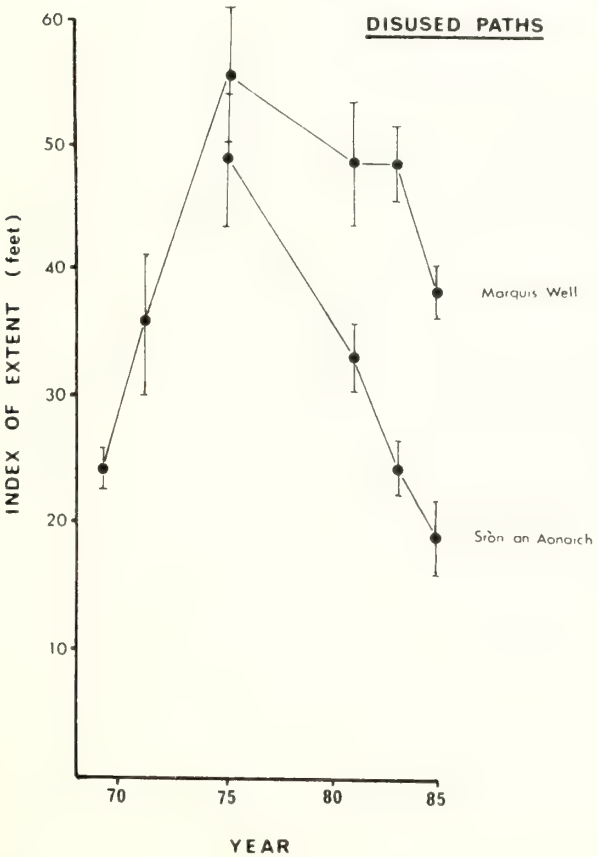

Figure 4.-- Changed in width ("index of extent" = total width + bare width) on the Marquis Wells path (heavily used to 1975, lighter use since then), and Sròn an Aonaich path (falling use since 1960, now little used), 1969-85. (±SE)

(notably *Juncus trifidus*) show that plant colonization must have begun almost as soon as use began to decline (P. Pryor, pers. comm.). The predominant vascular species colonizing path surfaces were *Calluna vulgaris* below about 2,600 ft (790 m) and *Juncus trifidus* on higher ground. Examination of the vegetation cover on the path and in adjacent ground shows considerable similarity of species composition, although with differing proportions of constituent species. The most striking difference is the higher cover of bryophytes on the path surface, particularly colonists of open ground such as *Polytrichum* species and *Orthotrichum hercynicum*. Presumably bryophytes will tend to decline in the longer term as the vascular cover becomes more complete. There were almost no non-indigenous species present, a contrast to similar paths at lower altitude, where a sequence of ruderals would be expected (Bates 1935).

The Marquis Well path originated in the late 1960's, and was used briefly as a vehicle track to the summit of Cairn Gorm. Pedestrian use was heavy up to about 1975, then fell when another route was signposted to the summit. Since then there has been a substantial decline in width because of colonization by bryophytes but so far there has been little colonization by vascular species. Some light use of the path continues, and this disturbance may be limiting colonization by these species.

Vehicle tracks

Vehicular tracks differ from paths in that only the running surface is liable to further disturbance. The verges and cut and fill slopes, which are often the most conspicuous elements of the track, can thus be readily invaded by vegetation (subject to constraints of climate, surface and propagule availability. Bayfield and others (1984) showed that colonisation of track verges was slow but progressive at all altitudes, with colonization by vascular species declining and cover by bryophyte species increasing with altitude (fig. 5).

Slope was another important variable, with cover declining with increasing slope. A mathematical model was derived relating vegetation cover to track age, altitude and slope. The model indicated that, for instance, at 3300 ft (1000 m) 40% cover by vascular species would take fifteen years.

Seeding and fertilising disturbed ground accelerate revegetation rates (Bayfield 1980). Figure 6 shows the vegetation cover and species composition of two seeded bare areas on Cairn Gorm from 1969-1985. The first area, a ski run, was seeded in 1967. By 1969 there was 40% cover of sown grasses and about 10% cover of mosses. The grass cover remained at a similar level for about ten years, but by 1985 (18 years) had fallen to 15%. Moss cover steadily increased, to 77% in 1985. Native vascular species colonized the sown sward very slowly. Cover was only 7% after 18 years, although 20 out of 40 random 0.1 m^2 quadrats included at least one native species. (The most frequent were *Juncus trifidus* (10 quadrats) *Empetrum nigrum agg.* (4), *Galium saxatile* (4), *Gnaphalium supinum* (5) and *Nardus stricta* (5).)

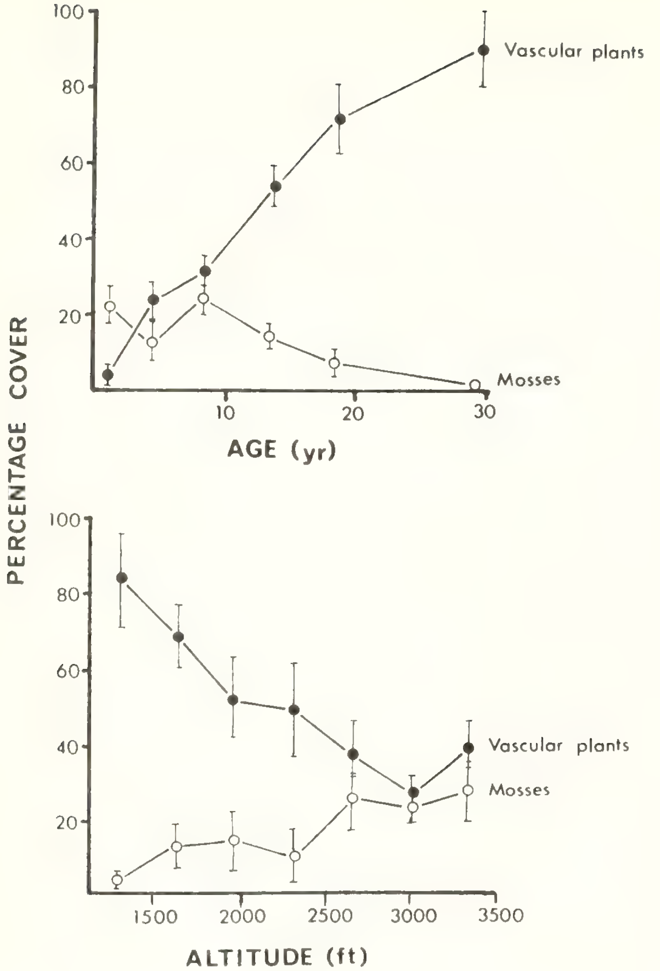

Figure 5.-- The cover (+SE) of vascular species (•) and mosses (o) on level or gently sloping track verges in relation to a) track age, and b) altitude of tracks 6-20 years old, in the Cairngorms Mountains (Bayfield and others 1984).

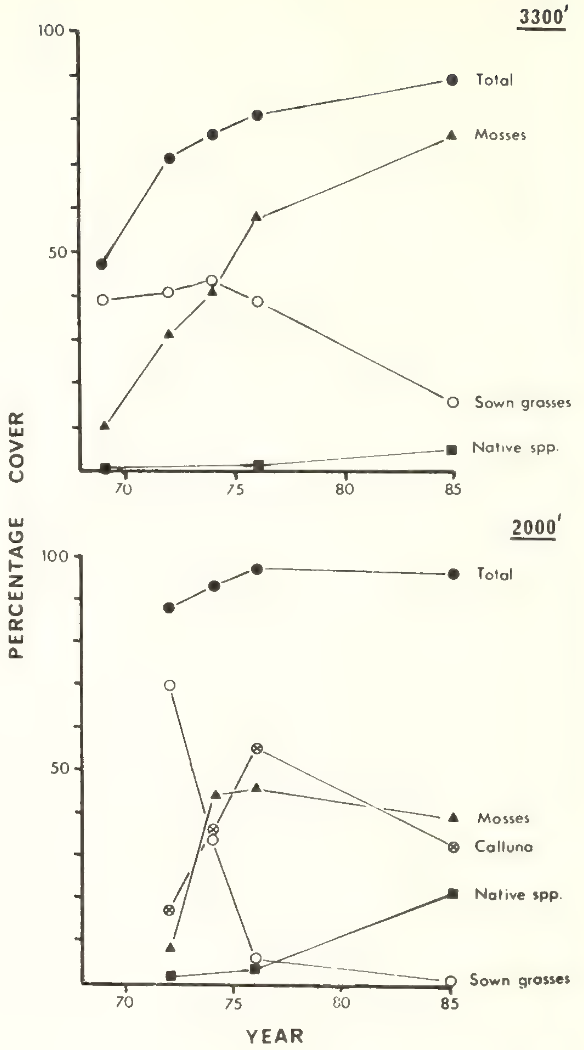

Figure 6.-- Cover of sown grasses, and colonization by mosses, heather (*Calluna vulgaris*) and other native vascular species, on seeded bare ground at 3300 ft (1000 m) and 2000 ft (600 m) on Cairn Gorm, 1969-1985.

Although sown grasses persisted they did not spread into surrounding undisturbed ground. After the first year, during which the newly sown grass looked intrusively bright green, the sown surfaces had greatly reduced visual impact by comparison with bare, untreated sites.

The second area was a road bank at 2000 ft (600 m), seeded in 1968, and first recorded in 1972. The high cover of grass recorded at the first analysis fell to a very low level by 1976, but there was vigorous colonization by *Calluna vulgaris* (heather), which peaked by 1976 and subsequently fell as other native vascular species colonized the sward (mainly *Erica* species, *Nardus stricta* and *Juncus squarrosus*). After about 6 years, the heather-colonized sown surfaces blended almost completely with the surrounding ground.

The upper altitudinal limit for heather is about 2,500 ft (750 m). The site at 3,300 ft is an example of ground above the heather zone, where, with no species taking a vigorous colonizing role, invasion by native vascular species is very slow.

These studies show that spontaneous colonization of spoil by native species gradually reduces the raw appearance of new tracks but that the process can be greatly accelerated by seeding newly disturbed surfaces.

DISCUSSION

The impact of vehicle tracks on wilderness is mainly perceptual, since the area of ground affected is small, and the ecological impacts limited. The existing penetration of remote ground is probably a permanent feature, since site restitution, although technically feasible, would be very costly. The visual impact is, however, probably at its worst shortly after construction, and should gradually lessen as time goes by, both as track spoil is colonised by local species, and as exposed boulders weather and are colonised by lichens and mosses. These growth processes contribute to making the presence of a vehicle route less offensive as revegetation reaches an advanced stage. This

revegation does not solve the perceptual impacts of track construction however.

Although public vehicular access is restricted on virtually all the Cairngorms tracks, this might not be the case when individual estates are sold, or if for some other reason there is a change of management policy. Public use of hill tracks could be very much more intrusive than the limited use by estate vehicles that takes place at present. Any such change of use is probably not covered by planning controls, but ought to be considered in future overall management strategies for the Cairngorms. Although few tracks have been built in the last five years, further expansion cannot be ruled out, and it seems opportune to consider greater control of new routes.

Footpaths are in a sense a more permanent impact since they are traffic-maintained, and further expansion and deterioration seem, on present trends, to be likely for at least the immediate future. Most new paths in the Cairngorms have been unplanned, and therefore fall outside the remit of statutory planning control. Even constructed paths can be built without prior approval, except in special circumstances (such as in Sites of Special Scientific Interest). Paths on mineral soil tend to be less worn than those on peat, some of the latter now being so worn and extensive as to be of considerable visual intrusion. Management of heavily used paths may require both rehabilitation of worn sections and channeling of visitors along preferred routes. Closing of paths may eventually lead to spontaneous colonisation on mineral soils but probably not on peat, where seeding and fertilization of devegetated ground may often be necessary. The provision of durable, well drained surfaces might help channel walkers and minimize further disturbance of vegetated path edges. Many outdoor people might find this kind of management intrusive in itself. Such techniques may, however, mainly be needed in well-used parts of the Cairngorms, and the sympathetic use of local materials, particularly local stone and gravel, could help restoration work blend in with the surrounding ground. At present the management of both people and paths is extremely rudimentary. Only one path (part of the Lairig Ghru) recorded by Bayfield (1985) showed signs of width reduction resulting from rehabilitation work. Tracks have been similarly neglected, with hardly any examples from the Cairngorms having been seeded, (apart from on the ski grounds at Cairn Gorm) and few having been subject to planning control.

One of the principal problems of achieving any overall standards or policy on access is that the area is fragmented into a mosaic of land ownership and overlain by three different regional government areas (Highland Region, Grampian Region and Tayside Region) and a variety of central government land designations (such as Site of Special Scientific Interest, National Nature Reserve, and Forest Park). Part but not all of the Cairngorms has development area status, being in the area of the Highlands and Islands Development Board. Even the National Nature Reserve offers only partial protection and has generally ineffectual management. Only 12% of the Cairngorms NNR is owned by the Nature Conservancy Council, the remainder being held by agreement with landowners, whose rights are only slightly curtailed by the designation. Similar areas in England of national landscape or cultural conservation importance have, since 1948, been designated as National Parks, with their own planning authorities, but the necessary legislation for Scotland has not so far been enacted. Conservationists have been pressing for some form of planning strategy for the Cairngorms area, and this will probably require something similar to National Park status (Watson 1984c). The need has been widely recognised and debated (Countryside Commission for Scotland 1974) and the discussion goes on. As recently as March 1985 the House of Commons Scottish Affairs Committee (1985) recommended the adoption of a single management strategy for the area. It is to be hoped that this will occur while there is still some wilderness left to conserve.

REFERENCES

Aitken, R. Scottish mountain footpaths. A reconnaissance review of their condition. Perth: Countryside Commission for Scotland; 1985. 97p.

Anderson Semens Houston. Environmental impact analysis. Proposed expansion of downhill skiing facilities at Coire an t-Sneachda, Coire an Lochain and Lurchers Gulley, Cairngorm. Glasgow: Anderson Semens Houston Environmental Design Partnership; 1981. 27p.

Bates, G.H. The vegetation of footpaths, sidewalks, cart-tracks and gateways. Journal of Ecology. 23: 470-487; 1935.

Bayfield, N.G. Burial of vegetation by erosion debris near chairlifts on Cairngorm. Biological Conservation. 6: 246-251; 1974.

Bayfield, N.G. Vehicular tracks in upland Scotland. Report to the Countryside Commission for Scotland. Banchory, Scotland: Institute of Terrestrial Ecology; 1976. 33p.

Bayfield, N.G. Replacement of vegetation on disturbed ground near ski-lifts in the Cairngorm mountains, Scotland. Journal of Biogeography. 7: 249-260; 1980.

Bayfield, N.G. The dynamics of heather (*Calluna vulgaris*) stripes in the Cairngorm mountains, Scotland. Journal of Ecology. 72: 515-527; 1984.

Bayfield, N.G. The effects of extended use on mountain footpaths in Britain. In: The ecological impacts of outdoor recreation on mountain areas in Europe and North America. Recreation Ecology Research Group Report No. 9. Wye, UK: Recreation Ecology Research Group, Dept. Horticulture, Wye College; 1985: 100-111.

Bayfield, N.G.; Moyes, S.M. The Stac Polly footpath - an occasional management research study. Edinburgh: Nature Conservancy; 1972. 10p. Mimeographed report.

Bayfield, N.G.; Penny, M.G.; Moyes, S.M. An indicator species analysis of map squares and vegetation in the Cairngorms. Transactions of the Edinburgh Botanical Society. 44: 35-47; 1982.

Bayfield, N.G.; Urquhart, U.H.; Rothery, P. Colonization of bulldozed tracks in the Cairngorm mountains, Scotland. Journal of Applied Ecology, 21: 343-354. 1984.

Bryan, R.B. The influence of soil properties on degradation of mountain hiking trails at Grövelsjön. Geograf. Ann. 59A(1-2): 49-65; 1977.

Countryside Commission. Pennine Way Survey. London: Countryside Commission; 1973, 78p.

Countryside Commission for Scotland. A parks system for Scotland. Perth, Scotland: Countryside Commission for Scotland; 1974.

Cunningham, G.M. Modified step pointing, a rapid method of assessing vegetation cover. Journal of Soil Conservation. 31: 256-265. 1975.

Curry-Lindahl, Kai; Watson, A.; Watson, D.R. The future of the Cairngorms. Aberdeen: The North East Mountain Trust; 1982. 47p.

Edinburgh University. Cairngorms area planning study. Edinburgh: University of Edinburgh Dept. of Urban Design and Regional Planning; 1978.

Green, F.H.W. Climate and Weather. In: Nethersole-Thompson, D; Watson, A.; The Cairngorms, their natural history and scenery. London: Collins; 1974. 228-236.

House of Commons Scottish Affairs Committee. Session 1984-85. Highlands and Islands Development Board. Vol. 1. Report and proceedings of the Committee. Edinburgh: Her Majesty's Stationery Office; 1985.

Miller, G.R.; Cummins, R.P. Regeneration of Scots pine *Pinus sylvestris* at a natural tree-line in the Cairngorm Mountains, Scotland. Holarctic Ecology. 5: 27-34; 1982.

Naylor, M.C. The impact of recreation on the vegetation and soils of Kinder Scout. Discussion Papers in Conservation, 16. London: University College; 1979. 37p.

Scottish Development Department. Cairngorms area. Report of the technical group on the Cairngorm area of the Eastern Highlands of Scotland. Edinburgh: Her Majesty's Stationery Office; 1967.

Watson, A. A survey of vehicular hill tracks in North-east Scotland for land-use planning. Journal of Environmental Management. 18: 345-353. 1984a.

Watson, A. Paths and people in the Cairngorms. Scottish Geographical Magazine. 100: 151-160; 1984b.

Watson, A. Wilderness values and threats to wilderness in the Cairngorms. In: Martin, Vance; Inglis, Mary, eds. Wilderness, the way ahead. Proceedings of the 3rd World Wilderness Congress, 1983. Findhorn Press; 1984c. 262-267.

Watt. A.S.; Jones, E.W. The ecology of the Cairngorms. 1. The environment and the altitudinal zonation of the vegetation. Journal of Ecology. 36: 283- 304. 1948.

PLANT AND SOIL RESPONSES TO WILDERNESS RECREATION:

A SYNTHESIS OF PREVIOUS RESEARCH

Fred R. Kuss, Alan R. Graefe, and Laura Loomis

ABSTRACT: Many studies have investigated the impacts resulting from increasing numbers of visitors to the nation's parks and forests. This paper summarizes previous research dealing with the impacts of wilderness recreation on vegetation and soils in the context of six major principles governing plant and soil responses to recreation use: (1) impacts may directly or indirectly affect plant and soil constituents of an ecosystem; (2) plants and soils vary in their sensitivities or resistance to different forms of impact; (3) the changed environment resulting from direct and indirect forms of impact selects for species best adapted to change; (4) responses of plants and soils to impacts are influenced by not only genetic or generic considerations but also by factors of their immediate environments; (5) the nature and magnitude of recreation impacts vary according to type of recreational activity; and (6) responses to impacts may be use intensity dependent or independent. Implications of these principles for the management of vegetation and soil impacts are discussed.

INTRODUCTION

For more than 50 years, scientists from several disciplines have reported results of their observations and studies dealing with the ecological impacts of recreational use of natural areas. This paper presents selected findings of a study designed to synthesize theoretical and empirical research derived from this body of knowledge. Conclusions were developed over a two-year period which involved extensive review of relevant published and unpublished literature, field visits to several national parks and discussion with park management staff.

Managing to control recreation impacts requires an understanding of the nature of impacts and the factors related to their occurrence. In preparing the synthesis it proved useful to highlight the major relationships described in previous research by formulating several principles. Among these are:

1. Recreation use of natural areas results in direct and indirect forms of impact to plants and soils.
2. Plants and soils vary in their sensitivities or resistance to impacts.
3. The changed environment resulting from direct and indirect impacts selects for species best adapted to change.
4. Site-specific factors influence change and rate of change resulting from recreational impacts.
5. Impacts vary by type of use.
6. Responses to impacts may be use intensity dependent or independent.

It is perhaps noteworthy that these same principles share a commonality with both the wildlife and social components of a broader synthesis of the carrying capacity literature. See Kuss and others (1984).

The format of this paper consists of a statement of the principle followed by a short summary of evidence supporting each principle. The paper was organized this way to identify major issues that need consideration when managing wilderness areas to reduce or control visitor impacts; to stress the complex ecological interdependencies of a recreation system; and to identify how these systems may respond to use. This information should serve as a foundation for developing management strategies and points to the problems of implementing the traditional view of carrying capacity when applied to wilderness areas.

PRINCIPLE: Recreation use of natural areas results in direct and indirect forms of impact to plants and soils

SUMMARY

Recreation may cause locally severe impacts on wilderness ecosystems. Under the pressures of use, plants are subjected to the direct physical forces of mechanical injury and indirectly to changes in the physical, chemical and biological characteristics of the growing medium. These collective effects result in impaired vital functions, a disordered utilization of energy, debilitation, and a high frequency of plant mortality (Hartley

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1976). Direct effects are manifested by signs such as stem breakage, crushed, torn or abraded foliage, mutilation, and dead and dying vegetation. These effects may extend below ground and result in root injury, decreases in the number of feeder roots, and reduction in the areal extent and volume of root mass active in nutrient and water uptake (Burger 1940; Johnson 1977; Meinecke 1982).

Among the symptoms of both direct and indirect impacts are defoliation, chlorosis, yellowing, leaf necrosis and spotting, aberrations in bloom, stunting, wilting, and dieback (Hartley 1976; Landals and Scotter 1973; Settergren and Cole 1970). These indicators are expressions of reduced photosynthetic surfaces and decreased carbohydrate synthesis, impaired energy metabolism, water and nutrient imbalances, reproductive failure, decreases in height and biomass, and disruption of the translocation process.

Indirect forms of impact alter the physical properties of the soil and its biological and chemical composition. Trampling and packstock/horse use causes soil compaction, increased soil density and penetration resistance, changes in soil structure and stability, losses in litter and humus layers, reduced infilitration rates, greater run-off and increased erosion (Cole and Shreiner 1981). Changes in the physical properties of soils are accompanied by changes in soil biology and chemistry. Altered macro/and microhabitats in the soil and litter result in major changes in the species composition of soil microflora and fauna (Duffey 1975; Duggeli 1937) and biochemical processes mediated by soil microorganisms which transform organic matter into plant nutrients may be altered (Rutherford and Scott 1979; Stohlgren 1982). While these effects are classed as indirect, the resulting changes directly affect plant establishment, growth, vigor, reproduction and completion of a normal life cycle.

PRINCIPLE: Plants and soils vary in their sensitivities or resistance to impacts

SUMMARY

Plants vary in their responses to impacts as do soils. Variations in plant responses to direct impacts are governed in large measure by the genetic constitution of the species. Leaf form, location of the perennating growing points, growth form, and length of activity are considered factors most important to species resistance (del Moral 1979). Of these, leaf form is thought to be the single most important morphological characteristic. Life and growth form features of plants reported to be most resistant to direct forms of impact are smallness, short shoot heights to flower heads, buds located at or just below the soil surface, flexible stems, sclerophyllous leaves and a rosette or cushion leaf arrangement (del Moral 1979; Frenkel 1970). As a rule, grasses and sedges have proven to be more resistant to impacts than other growth forms (Cole 1979).

Factors internal to the ecosystem such as stage of succession, species composition and diversity, inter and intra-species competition and beneficial or antagonistic associations influence both species and community resistance. Plants growing under conditions of severe internal stress are predisposed to a higher degree of susceptibility to external stress factors such as recreational use. For example, the same species growing in pure stands are reported to be more sensitive to trampling than when growing in mixed stands (Holmes and Dobson 1976). In this example, the greater sensitivities of plants growing in pure stands can be explained to be the result of an intense competition for space, water, light, and nutrients creating a high level of internal stress in the community (Odum 1971). When growing in a mixed community the competition is lessened due to a diversity of requirements for these factors at different times during the growing season.

Beneficial associations between plants and/or other organisms include commensal and mutalistic associations where one or both organisms derive some form of benefit from its associate, such as the production of growth substances, antibiotics, or other elements that reduce physiological stress. Mycorrhizal relationships, which are good examples of a mutual association, are reported to be seriously impaired in disturbed environments (Moorman and Reeves 1979). Few antagonistic associations have been reported in recreational literature. However, a recent study mentions the proliferation of a non-native plant species in the Boundary Waters Canoe Area that produces substances toxic to many native species giving the invader a strong competitive advantage in this wilderness setting (Marion and Merriam 1985). It may be inferred that plants weakened by sublethal levels of this toxicant would be more susceptible to injury by trampling than healthy individuals.

Soils vary in generic constitution in terms of parent material, texture, and structure. These variables influence complex interactions between impacting forces and the physical properties of a given soil. The behavior of soils under the pressures of recreation use is greatly determined by whether the soils are of coarse, medium or fine texture which vary in their porosity and moisture holding capacities. These differences influence compactibility, bulk density change, drainage properties, plasticity, bearing capacity and erodibility. As a general rule, medium texture, non-plastic, moderately well-drained soils of moderate bulk density are most resistant to changes inimical to plant growth. Changes most important to plant growth are reductions in water transmission and water balance, increased soil bulk density and penetration resistance, increased erodibility, and decreased aeration (Whisler and others 1969).

Compaction hazards are not only influenced by texture but also are moisture dependent in terms

of degree of change. For example, fine cohesive soils change in consistency under different moisture regimes. Consequently, under increasing levels of moisture, these soils become less resistant to compaction and have less capability to carry traffic without deformation or displacement. Conversely, sands have greater density and trafficability properties when wet (Marshall and Holmes 1979).

Factors internal to the ecosystem may also influence the relative sensitivities of soils to changes harmful to plant growth. These include soil position in the landform, rockiness, depth to seasonal high water table, depth to bedrock or hardpan, rooting depth, age of soil, soil stability, and rate of nutrient recycling (Leonard and Plumley 1979; Leeson 1979).

PRINCIPLE: The changed environment resulting from both direct and indirect impacts selects for species best adapted to change

SUMMARY

As plant habitats are modified by the impacts of recreational use, the changed environment selects for more resistant plant species. These may be members of the original community or opportunistic, more aggressive plant invaders which displace native flora. Depending upon the level of stress and amount of continued use, major changes in both community structure and diversity may result (Lemons 1979; Coombs 1976; Landals and Scotter 1973). Should the disturbed area continue to be used, the soil mantle may be irreversibly damaged by loss of stability and erosion (Goldsmith 1974).

Several reports indicate that native plant species are replaced by weedy invaders on impacted areas. Recolonization of these areas is most frequently represented by species found also to be resistant to trampling (Easterbrook 1969; Foin 1977; LaPage 1967; Lemons 1979; Peters 1972). The rosette, tufted and cushion growth form are most often associated with these species. Generally the more aggressive species belong to the following genera: Poa, Agrostis, Carex, Trifolium, Taraxacum, Plantago, Festuca, Deschampsia, and Phleum, (Devos and Bailey 1970; Liddle 1975; Marchand and Spencer 1977; Monsen 1975; Peters 1972; Ranz 1979; Spiridinov 1979). The consistency of these reports suggests that not only is morphology involved but also the capability of these species to cope with increasing soil densities, moisture and nutritional stress and other adverse soil conditions caused by trampling.

Reconditioning impacted sites requires loosening of the compacted soils to create favorable rooting media, fertilizer application to encourage plant establishment, stabilization of barren soils by netting, and means to conserve moisture. These factors thus represent products of change in the soil environment which follow recreational impact of natural areas and which previous to impact were sufficient to support stands of native flora (Cole and Schreiner 1981).

PRINCIPLE: Site-specific factors influence change and rate of change resulting from recreation impacts

SUMMARY

Site specific factors of the habitat environment influence in great measure the rate and extent of change resulting from wilderness recreation. Factors considered most important to the nature of plant responses to impacts include the amount and kinds of forest floor cover, the amount of organic matter and clay content in the soil, soil moisture, elevation, percent overstory density, slope variation, and aspect (del Moral 1979).

Composition and thickness of the forest floor function to cushion the effects of trampling, to reduce the impacts of rainfall and in reducing foot compaction hazards and subsequent deterioration of soil as a medium for plant growth (Faye 1977; Lesko 1973). The litter layer under coniferous overstories is reported to confer greater durability to use than those under deciduous cover (Cole 1984; Legg 1973). Fibrous mor humus mats overlying the mineral soil offer greater stability than in locations where rapid decomposition and incorporation of the LFH layers occur. Depth of the litter-humus layer is also important since plant and tree roots tend to concentrate in thick layers increasing the hazard of exposure during prolonged wear intensive use. Because of the impervious nature of clays to water when compacted, their plasticity under weight loads, low bearing strength when wet, and their shrink swell properties, soils with high clay fractions are considered to be the least desirable for campsite use (Lesko 1973).

Plants growing under conditions of moisture excesses or deficiencies respond differently to impacts. For example, the same plant species growing in moist, wet habitats have been found to be more sensitive to impacts than when growing under dry conditions. On the basis of extensive field observations both Price (1983) and Cole (1984) suggest that gradients of plant resistance follow moisture gradients. It is known that wet habitats are more quickly denuded by trampling than dry areas (del Moral 1979); however, these same habitats may recover more rapidly after the stress levels are removed (Cole 1984). Gradients of plant sensitivity also appear to follow gradients in elevation due to the moisture variable and length of growing season (Leonard and others 1980; Price 1983).

Density of the overstory canopy has been reported to influence the severity or degree of understory damage (Hart 1982; Schreiner and Moorhead 1976). It may be generalized that herbaceous plants growing under closed canopies are much more

sensitive to impact than those growing under canopies or in full sun suggesting that both anatomical and structural dissimilarities may account for these differences. According to Daubenmire (1974) comparisons of sun and shade plants indicate that sun plants are less succulent, have shorter internodes, thicker stems, less leaf area, and thicker cuticles and cell walls, characteristics that reduce vulnerability to impacts (Cole 1979; Liddle 1975). Many species growing in full sunlight are prostrate while those growing in shade are quite often erect thus increasing their susceptibility to injury (Daubenmire 1974). These considerations as well as those associated with water imbalances implicate slope, aspect, and elevation as variables influencing length of growing season, moisture and temperature regimes, depth of soil, soil durability and plant distribution. Slope mediates in great measure soil stability and erodibility while elevation and aspect influence moisture variations, the form and structure of plants growing in different environments and the likelihood that gradients of resistance will occur.

Since plants must physiologically integrate all factors of their environments to survive, physical factors of the habitat may exert sufficient stress to overcome the genetic advantages associated with morphological resistance. Consequently, the rapidity by which plant communities decline under recreation pressures may be due to habitat factors. This observation has prompted ecologists to suggest that assessments of plant resistance should not be separated from a characterization of the habitat in which plants under study grow.

PRINCIPLE: Impacts vary by type of use

SUMMARY

Primary activities associated with wilderness use include camping, hiking and backpacking, wildlife viewing, angling, use of packstock and horseback riding, rafting and canoeing. When such activities take place in natural unmodified settings, some change is inevitable.

Few studies have compared the impacts of different activities and those that have are appropriate only in part to activities associated with wilderness recreation. Liddle and Greig-Smith (1975) compared the effects of vehicle use to picnicking and walking on the species composition and diversity of sand dune plant cover. Their findings indicated that vehicle use was roughly three times more damaging than picnicking and picnicking sevenfold that of footpath use. Weaver and Dale (1978) compared three modes of travel on forested and meadow systems. Hiking was less damaging than either motorcycle or horse travel in terms of percent bare ground, trail width and depth while cycle use was less damaging than horse travel. Kuss and Jenkins (1985); Kuss (1983); Saunders and others (1980); and Palmer (1972) have compared the impacts of hiking wildland trails with different designs of footgear. No differences could be demonstrated between popular types of hiking boots, as measured by erosion or boot transport of soil.

While data gaps exist in comparative studies dealing with differences between activities and their impacts on natural areas, it may be inferred that the following differences would occur given equal intensities of use on similar environments.

1. Hiking with a pack is more damaging to trail wear than hiking without a pack (Saunders and others 1980).
2. Walking or hiking is less damaging to vegetation than camping on the same surfaces in terms of vegetation destruction and exposed bare ground (Landals and Scotter 1973)
3. Pack stock and horse travel is considerably more damaging to trails than hiking with or without a pack (Frissell 1973; Laing 1961; Strand 1972; Weaver and Dale 1978).
4. Use of pack stock and horses reduces forage available to wild ungulates and may introduce exotic species (Ream 1979).
5. Large group camping is more damaging to the environment than small group camping (Bratton and others 1973)
6. When concentrated in a comparatively small area, angling can be more damaging to shoreline stability and vegetation than wildlife viewing (Liddle and Scorgie 1980).
7. Canoeing is less damaging to shoreline stability than rafting or power boating (Liddle and Scorgie 1980).
8. Concentrations of any activity in comparatively small areas may be less ecologically damaging in the long term than dispersed use without restrictions. (Cole 1984; Thornburgh 1985).

These generalizations have their exceptions as is the case with evidence which is in part presumptive and because environmental variables and site-specific factors influence responses to use (Bratton and others 1977). For example both Bell and Bliss (1973) and Williard and Marr (1970) report major disturbances to alpine flora with limited walking and Cole (1982) reports major environmental damage to wilderness campsites by very limited use.

PRINCIPLE: Impacts vary by amount of use

SUMMARY

Use relationships to damage assume the dimensions of rate, degree, and extent of change. Rate of change appears to be not only a function of the level of use, but also an expression of plant interactions with habitat variables such as

moisture levels, aspect, elevation, temperature, organic cover, plant density and soil texture (del Moral 1979). For many ecosystems, the degree of damage has been shown to be independent of use intensities, since light use has been reported to bring about the greatest degree of change in several key impact parameters (Allcock 1973; Bell and Bliss 1973; Cole 1982; Jones 1978; Landals and Scotter 1973, 1974; Merria and others 1973; Nagy and Scotter 1974; Singer 1971). The extent of damage increases with the amount and duration of use and can be said to be use dependent or primarily a function of the number of users on habitats studied to date (Bratton and others 1977; Merriam and others 1973).

The rate at which different ecosystems respond to the effects of trampling is highly variable (Cole 1984; Hartley 1976; Liddle 1975; Landals and Scotter 1973; Nagy and Scotter 1974; Weaver and others 1979). When the number of trampling passes required to reduce the original plant cover by 50 percent is used as a measure of difference between systems, as much as a 73 fold difference between the most and least sensitive system has been demonstrated. While the data are limited, these results suggest that the herbaceous forested forb cover will decline at a much faster rate than grasslands or meadows, supporting the contention that graminoid species are more highly resistant or tolerant to use (Cole 1979).

The weight of evidence indicates that the response of ground cover vegetation to different use intensities is curvilinear for several systems studied to date. Under conditions where responses to varying levels of use are investigated at the same time, findings indicate that most damage occurs quickly as a result of light use, with relatively little additional impact as use increases. Several investigators have reported greater differences between undisturbed and lightly used areas than between light and heavily used areas. These responses have been reported for alpine systems (Bell and Bliss 1973; Hartley 1976; Landals and Scotter 1974) chalk grasslands (Allcock 1973), heather communities (Bayfield and Brookes 1979) boreal forested conditions (Cole 1982; Merriam and others 1973), sand dune vegetation (Boorman and Fuller 1977), spruce forest understory (Kellomaki 1973), tundra (Hudson 1977), and subalpine systems (Cole 1982; Hartley 1976).

Few studies have separated the intensity of damage from the extent of damage. A notable exception is the work of Merriam and others (1973) conducted over a five-year period to assess changes in newly developed campsites of the Boundary Waters Canoe Area. Their conclusions were that the greatest intensity of site damage expressed in ground cover loss, increased soil bulk density, tree damage and loss of organic matter occurred under low use (peaking at two years of use). The extent of damage reflected in size of the impacted area was both time and cumulative use related. It may be generalized that the greatest extent of damage is based upon the cumulative effects of use over time, up to a point where an equilibrium is reached between the spatial requirements for the activity and the areal damage of a given area. Unchanneled movement through the system such as the development of social trails between campsites may increase extent of damage. This problem appears to be directly related to the number of campsites concentrated in the camping area, the frequency of use, the size of the party visiting the area, and accessibility to the camping area (Bratton and others 1973). As observed by Bratton and others (1977) and Bogucki and others (1975), the extent of damage appears to be a function of group size and number of users rather than the frequency of use.

CONCLUSIONS

A three-way interaction appears to mediate plant responses to impacts; plant x environment x stress factor(s). Plant responses in turn vary according to the genetic constitution of the plant as reflected by life and growth form, the adaptive flexibility of the plant, and anatomical differences inherent to growth habit and morphology.

Environmental influences center on the effects of physical factors such as elevation, aspect, length of frost-free season, moisture and temperature on plant growth as well as biological interactions such as intra and interspecific competition, antagonism or beneficial associations and species composition of the plant community. Habitats may be classed as resistant or highly sensitive to impacts.

Seasonal influences also bear consideration since environmental changes and phenological and physiological events are mediated by time of year. Consequently, the degree of impairment to the system that might occur under similar levels of use may vary according to season. The stress factor(s) may directly or indirectly affect plant cover through the interdependencies that link together the biotic components of an ecosystem. Stress levels vary according to the intensity of use, the frequency of use, season of use, and the use activity. These stresses cause modification of the existing habitat. The modified environment selects for those species best adapted to change and displacement of native species may occur resulting in a rearrangement in community structure in terms of species composition, dominant influences, species diversity and abundance. The same may be said for the associated microflora and fauna of the original undisturbed habitat. Impacted habitats may require several to hundreds of years to recover to their previous status depending on the severity of the impact and prevailing conditions that influence plant establishment, growth, and reproduction.

Future research is needed to define the causal factors that mediate the curvilinear relationship of plant cover decline with use levels. Continued research aimed at determining the

number of impacts required to reduce the original plant stand by 50 percent should be encouraged since it provides a basis for comparing different plant communities in terms of their levels of sensitivity to recreational use. However, these responses must also be defined by the dimension of habitat variables and should be followed by companion studies dealing with recovery rates since this is also a factor in the capacity equation.

Principles of carrying capacity such as presented in this paper serve a better understanding of the causal relationships influencing plant and soil responses to impact and as a foundation for planning-management principles being developed for establishing capacity standards. Progress has been made in the past few years toward a better understanding of impact ecology; however, much more information is needed to explain the etiology and ecological consequences of plant-environment-stress interactions resulting from various activities associated with wilderness use.

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REFERENCES

Allcock, P. J. Treading of chalk grassland. Journal of Sports Turf Research Institute. 49: 21-28; 1973.

Bayfield, N. G.; Brookes, B. S. Effect of repeated use of an area of heather. Biological Conservation. 5(1): 25-32; 1973.

Bell, K.; Bliss, L. C. Alpine disturbance studies: Olympic National Park, U.S.A. Biological Conservation. 5(1): 25-32; 1973.

Bogucki, D. J.; Malanchuk, J. L.; Scheneck, T. E. Impact of short term camping on ground level vegetation. Journal of Soil and Water Conservation. 30(5): 231-232; 1975.

Boorman, L. A.; Fuller, R. M. Studies on the impact of paths on the dune vegetation at Winterton, Norfolk, England. Biological Conservation. 12(3): 203-216; 1977.

Bratton, S. P.; Hickler, M. G.; Graves, J. H. Visitor impact on backcountry campsites in the Great Smoky Mountains. Environmental Management. 2: 431-442; 1978.

Bratton, S. P., Hickler, M. G.; Graves, J. H. Trail and campground erosion survey for Great Smoky Mountains National Park. U.S. Department of Interior, National Park Service Management Report No. 16, Washington, D.C.; 1977.

Burger, H. Physikalische Eigenschaften von Wald und Freilandboden, vi der Wals als Erhourgss-tatte und der Waldboden. Schweiz. Anst. Forstl. Verschsw. Mitt. 21: 223-249; 1940.

Cole, D. N. Reducing the impact of hikers on vegetation: An application of analytical research methods. In: Ittner, Ruth; Dale, R.; Agee, James K.; Anschell, Susan, Editors. Proceedings--recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service. Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979. 71-78.

Cole, D. N. Wilderness campsite impacts: Effects of amount of use. Research Paper INT-284. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 34 p.

Cole, D. N. Recreation use effects on habitat types in Western Montana. [In press].

Cole, D. N.; Schreiner, E. G. Impacts of backcountry recreation: Site management and rehabilitation--an annotated bibliography. General Technical Report INT-121. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 58 p.

Coombs, E. A. The impacts of camping on vegetation in the Bighorn Crags, Idaho Primitive Area. Moscow, ID: University of Idaho; 1976. 63 p. M.S. thesis.

Daubenmire, R. F. Plants and environment. New York: John Wiley & Sons; 1974. 422 p.

del Moral, R. Predicting human impact on high elevation ecosystems. In: Ittner, Ruth; Potter, Dale R.; Agee, James K.; Anschell, Susan, Editors. Proceedings--Recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979; 1979; 292-303.

deVos, A.; Bailey, R. H. The effect of logging and intensive camping on vegetation in Riding Mountain National Park. The Forest Chronicle. 49-55; 1970.

Duffey, E. The effects of human trampling on the fauna of grassland litter. Biological Conservation. 7(4): 255-274; 1975.

Duggeli, M. Wie Wirkt das Oftere Betreten des Waldbodens auf Einzeline Physikatlische und Physikatlische und Biologische Eigenschalften? Schweiz A. Forstwes. 88: 151-165; 1937.

Esterbrook, A. L. The effects of soil compaction on the occurrence of vegetatively reproducing plants in campsites. Ann Arbor, MI: University of Michigan; 1969. 90 p. M.S. thesis.

Fay, S. Technical resource data-presidential unit plan. Appendix E. White Mountain National Forest. Laconia, NH: 1977, 56 p.

Foin, T. C., Jr. ed. Visitor impacts on national parks: The Yosemite ecological impact study. Institute of Ecology, University of California; 1977. 99 p.

Frenkel, R. E. Ruderal vegetation along some California roadsides. University of California Publ. Geography; 1970; 20: 1-163.

Frissell, S. S. The impact of wilderness visitors on natural ecosystems. U.S. Department of Agriculture, Forest Service, Forestry Sciences Laboratory. Missoula, MT; 1973. 60 p. Unpublished Report.

Goldsmith, F. B. Ecological effects of visitors to the countryside. In: Warren, A.; Goldsmith, F. B., eds. Conservation in Practice. London: Wiley; 1974: 217-232.

Hart, J. B. Jr. Ecological effects of recreation use on campsites. In: Countryman, D. W.; Sofranko, D. M., eds. Guiding land use Decisions. Baltimore, MD: The John Hopkins University Press; 1982: 150-182.

Hartley, E. A. Man's effects on the stability of alpine and subalpine vegetation in Glacier National Park. Durham, NC: Duke University; 1976. 258 p. Ph.D. dissertation.

Holmes, D.O.; Dobson, E. M. Ecological carrying capacity research: Yosemite National Park. Part I. The effect of human trampling and urine on subalpine vegetation-A survey of past and present backcountry use and the ecological carrying capacity of wilderness. Springfield, VA: U.S. Department of Commerce National Technical Information Service; 1976. 247 p.

Hudson, M. Fortymile River: Biological aspects of carrying capacity. Tok, AL. U.S. Department of Interior, Bureau of Land Management. Unpublished Report; 1977. 52 p.

Johnson, G. Changes in the fine root rhizophere of white oaks from forest to lawn conditions, Western Illinois University, IL; 1977. 70 p. M.S. thesis.

Jones, D. H. The effect of pedestrian impact on selected soils. University of Glascow, Scotland; 1978. 154 p. M.S. thesis.

Kellomaki, S. Ground cover response to trampling in a spruce stand of Myrtillus type. Silva Fern. 7: 96-113; 1973.

Kuss, F. R. Hiking boot impacts on woodland trails. Journal of Soil Water Conservation. 38(2): 119-121; 1983.

Kuss, F. R.; Graefe, A. R.; Vaske, J. J. Recreation impacts and carrying capacity: A review and synthesis of ecological and social research. Report submitted to the National Parks and Conservation Association, Washington, D.C.; 1984. 181 p.

Kuss, F. R.; Jenkins, W. A. A summary of five years of backcountry research: Effects of foot gear design on trail wear. In: Proceedings of Southeastern Recreation Researchers Conference, Asheville, NC, February 1984.

Laing, C. C. A report on the effects of visitors on the natural landscape in the vicinity of Lake Solitude, Grand Teton National Park, Wyoming. U.S. Department of Interior, National Park Service. Unpublished report; 1974. 197 p.

Landals, M.; Scotter, G. W. Visitor impact on meadows near Lake O'Hara, Yoho National Park. Unpublished report. Canadian Wildlife Service, Edmonton, Alberta; 1973. 184 p.

LaPage, W. F. Some observations on campground trampling and ground cover response. Research Paper NE-68. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1967. 11 p.

Leeson, B. F. Research on wildland recreation impact in the Canadian Rockies. In: Ittner, Ruth; Potter, Dale R.; Agee, James K.; Anschell, Susan, Editors. Proceedings--Recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979. 64-65.

Legg, M. Site factors useful in predicting deterioration of forest campsites in Northern Michigan. East Lansing, MI: Michigan State University; 1973. 99 p.

Lemons, J. Coefficient of community and carrying capacity for a subalpine meadow. In: Proceedings, Second Conference on Scientific Research in the National Parks; San Francisco, CA: U.S. Department of Interior, National Park Service; 1979: 9: 33-60.

Leonard, R.; Plumley, H. J. The use of soils information for dispersed recreation planning. In: Ittner, Ruth; Potter, Dale R.; Agee, James K.; Anschell, Susan, Editors. Proceedings--Recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979. 50-63.

Leonard, R. E.; Spencer, E. L.; Plumley, H. J. Guidelines for backcountry facilities: Design and maintenance. Appalachian Mountain Club, Boston, MA; 1980.

Lesko, G. L. A preliminary site capability rating system for campground use in Alberta, For Res. Cent. Inf. Rep. NOR-X-45. Edmonton, Alberta; 1973. 16 p.

Liddle, M. J. A selective review of the ecological effects of human trampling on natural ecosystems. Biological Conservation. 7(1): 17-36; 1975.

Liddle, M. J.; Scorgie, H. R. A. The effects of recreation on freshwater plants and animals: A review. Biological Conservation. 17(2): 183-206; 1980.

Marion, J. L.; Merriam, L. C. Recreational impacts on well-established campsites in the Boundary Waters Canoe Area Wilderness. St. Paul, MN: University of Minnesota Agricultural Experiment Station, Bulletin No. AD-SB-2502; 1985. 16 p.

Marshand, P.; Spencer, E. Progress Report. Boston, MA: Franconia Ridge Alpine Vegetation Study; Appalachian Mountain Club; 1977. 9 p.

Marshall, T. J.; Holmes, J. W. Soil physics. London: Cambridge University Press; 1979. 345 p.

Meinecke, E. P. The effect of excessive tourist travel on the California Redwood Parks. Sacramento, CA: California State Printing Office; 1928. 20 p.

Merriam, L. C., Jr.; Smith, C. K.; Miller, D. E.; [and others]. Newly developed campsites in the Boundary Waters Canoe Area - A study of five year's use. St. Paul, MN: University of Minnesota, Agricultural Experiment Station Bulletin No. 511; 1973. 27 p.

Monsen, S. D. Selecting plants to rehabilitate disturbed areas. In: Campbell, R. S.; Herbel, C., eds. Disturbed Range Plants. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1975.

Moorman, T.; Reeves, F. B. The role of endomycorrhizae in revegetation practices in the semi-arid West. A biomassey to determine the effect of land disturbance on endomycorrhizal populations. American Journal of Botany. 66: 14-18; 1979.

Nagy, J. A. S.; Scotter, G. W. A quantitative assessment of the effects of human and horse trampling on natural areas. Waterton Lakes National Park, Edmonton, Alberta: Canadian Wildlife Service; 1974. 145 p.

Odum, E. P. Fundamentals of ecology. Philadelphia: W. B. Saunders Company; 1971. 574 p.

Palmer, R. Human foot impact. Wilderness impact study report. September 1972. The Sierra Club Outing Committee; 1972: 15-25.

Peters, J. E. The ecological implications of trail use. Cypress Hills, Alberta: University of Alberta, Edmonton; 1972. 159 p. M.S. thesis.

Price, M. P. Management planning in the Sunshine Area of Canada's Baniff National Park. Parks. 7(4): 6-10; 1983.

Ranz, B. Closing wilderness campsites: Visitor use problems and ecological recovery in the Selway-Bitterroot Wilderness, Missoula, MT: University of Montana; 1979. 125 p. M.S. thesis.

Ream, C. H. Human-wildlife conflicts in backcountry: Possible solutions. In: Ittner, R.; Dale, R.; Agee, James K.; Anschell, Susan, Editors. Proceedings--Recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979. 139-152.

Rutherford, G. K.; Scott, D. C. The impact of recreational land use on soil chemistry in a provincial park. Park News. 15: 22-25; 1979.

Saunders, P. R.; Howard, G. E.; Stanley-Saunders, B. A. Effect of different boot sole configurations on forest soils. Clemson, SC: Clemson University, Department of Recreation and Park Administration Extension, Research Paper RPA 1980-3; 1980. 11 p.

Schreiner, E. S.; Moorhead, B. B. Human impact studies in Olympic National Park Backcountry. Proceedings, Symposium on Terrestrial and Aquatic Ecological Studies of the Northwest. Cheney, WA: East Washington State College; 1976: 59-66.

Settergren, C. D.; Cole, D. M. Recreation effects on soil and vegetation in the Missouri Ozarks. Journal of Forestry. 68(4): 231-233; 1970.

Singer, S. W. Vegetation response to single and and repeated walking stresses in an alpine ecosystem. Brunswick, NJ: Rutgers University; 1971. 69 p. M.S. thesis.

Spiridinov. V. N. Change in species composition of the herbage in herb birch forest under the effect of recreational stress. Sov. J. Ecol. 9: 377-379; 1979.

Strand, S. An investigation of the relationship of packstock to some aspects of meadow ecology for seven meadows in Kings Canyon National Park. San Jose, CA: California State University; 1972. M.S. thesis.

Thornburgh, D. A. Responses of vegetation to different wilderness management systems. [In press].

Weaver, T.; Dale, D. Trampling effects of hikers, motorcycles and horses in meadows and forests. Journal of Applied Ecology. 15(2):451-458; 1978.

Weaver, T.; Dale, D.; Hartley, E. The relationship of trail conditions to use, vegetation user, slope, season, and time. In: Ittner, Ruth; Potter, Dale R.; Agee, James K.; Anschell, Susan. Editors. Proceedings--Recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979. 250-252.

Whisler, F. D.; Engle, C. F.; Boughman, N. M. The effects of soil compaction on nitrogen transformation in the soil. Morgantown, WV: West Virginia University, Agricultural Experiment Station. Bulletin 516T; 1965.

Willard, B. E.; Marr, J. W. Effects of human activities on alpine tundra ecosystems in Rocky Mountain National Park, Colorado. Biological Conservation. 2(4):257-255; 1971.

USE IMPACTS ON THE APPALACHIAN TRAIL

John H. Burde and James R. Renfro

ABSTRACT: The quantity of trail impact on the Appalachian Trail in Great Smoky Mountains National Park, as measured by cross-sectional area loss, was related to soil type, vegetation type, precipitation, and trail slope. Trail depth was related to soil type, vegetation type, elevation, precipitation, trail slope, and visitor use. Trail width was related to soil type and vegetation type. Impacts were generally highest in the spruce-fir type and on sandy loam soils. Site factors, including soil information, were not found to be useful in predicting the location or intensity of future impacts.

INTRODUCTION

Park managers are continually faced with accommodating increasing numbers of visitors while staff and budgets are shrinking. This difficult challenge can best be met by increased efficiency in the use of available resources. One approach is to seek methods to reduce expenditures while maintaining resource quality.

Opportunities for cost savings must be sought in all areas of park operations. Maintenance costs are a prime target, especially since maintenance expenditures are typically the largest component of a park's budget. According to National Park Service (NPS) estimates (1978), maintenance expenditures exceed the sum of all other expenditures (table 1).

Table 1.--Expenditures per visitor by activity[1]

Management activity	Cost per visitor
Maintenance	50¢
Resource management	16¢
Visitor protection & safety	13¢
Interpretation	11¢

[1]Source: NPS, Albright Training Center (1978)

These general comments apply as well to maintenance in backcountry areas. Many of the most popular trails and backcountry campsites in the United States were constructed during the Civil Conservation Corps era and have received minimal maintenance since that time. Many were built with little thought to proper design. Cole (1978) notes that poor location is the major cause of backcountry trail maintenance problems.

Trail maintenance has generally been reactive in nature. Typically an annual backcountry inventory identifies those trail segments and backcountry facilities in need of remedial action. Tasks are prioritized and completed as funding allows. However, due to lack of sufficient funds, maintenance is frequently deferred. The end result often is a more severe problem later, more costly to repair.

Minor repairs on trails (such as, replacing water bars) and in backcountry campsites may be relatively easy to accomplish and inexpensive to complete compared to repairing extensive impacts such as trail washouts. A means of predicting where impacts may occur in the backcountry based on physical characteristics of the site and the amount of use the site receives would be useful in two ways:

(a) to provide guidelines for carrying out preventive maintenance in the backcountry, for example, to identify backcountry areas that are likely to become severely impacted so that routine minor maintenance can prevent more severe problems later, and

(b) to provide guidance in the location of new trails so that future maintenance problems will be minimized.

The objectives of the study reported here were: (1) to sample the Appalachian Trail (AT) within Great Smoky Mountains National Park (GSMNP) to identify the incidence and quantity of soil movement and to describe the physical characteristics of the trail and (2) to develop a model to predict the incidence and quantity of trail impact as a function of site and use characteristics.

PREVIOUS WORK

Numerous research studies have been conducted in the area of backcountry impacts. Most of the previous research on trail impacts has been related to the causes of such impacts. Bates (1935) did some of the earliest work on trail impacts. He looked at trampling effects on vegetation and soil and examined the vegetational gradient perpendicular to trails, from bare soil to natural vegetation.

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Impacts on trails in the backcountry have been shown to be related to site characteristics (Willard and Marr 1970; Bayfield 1973) and use (Dale and Weaver 1974). The type of use, hiking or horseback riding, is also an important factor, as shown by McQuaid-Cook (1978), Weaver and Dale (1978), and Whittaker (1978).

Monitoring trail impacts can help alert managers to the deterioriation of trails. Several monitoring methods are available (Coleman 1977). Trails in the Adirondacks, for example, have been monitored for several years. Ketchledge and Leonard (1970) found trails in that area to be increasing in both width and depth at a rate of 2.5 cm (1 in.) per year. Leonard and Whitney (1977) also developed a trail transect system in the Adirondacks to measure soil loss as well as changes in trail width and vegetation.

Helgath (1975) studied the relationship of environmental factors to trail deterioration in the Selway-Bitterroot Wilderness of Idaho and Montana. Amount of trail erosion was measured as the cross-sectional loss (figure 1). This gives an objective measure of soil loss of a particular point. She contended that landform, vegetation type, and trail slope were highly related to trail erosion. Aspect, elevation, parent material, and amount of use were not related to amount of erosion in any consistent way. Her paper emphasized that no statistically significant correlation between use and amount of erosion could be discerned.

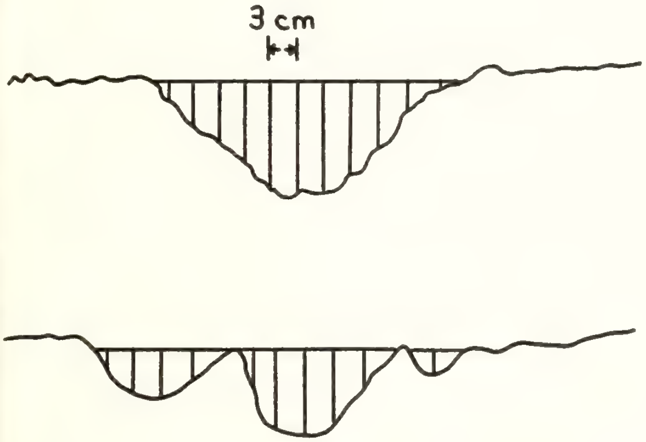

Figure 1.--Cross-sectional area loss. Source: Helgath (1975).

Helgath suggested that soil characteristics, such as infiltration rates, cobble content, and texture, which were not included in her study, might be related to trail deterioration and could possibly be considered important factors.

In 1977, a survey of the deterioration of trails and campsites in the backcountry in Great Smoky Mountains National Park was conducted by the Park's Uplands Field Research Lab. The methodology of the trail survey is reported in Bratton and others (1977); the results in Bratton and others (1978). The study reported that trail problems were more extensive in areas with heavy horse use, in spruce-fir forests and early successional vegetation, and on certain trail slopes. Trail impacts are more a function of location, design, and type of use rather than amount of use.

The study reported here used the methodology of Bratton and others (1977) to evaluate impacts on the Appalachian Trail within the Park. Instead of using a somewhat subjective estimate of impact, as was done in 1977, Helgath's (1975) cross-sectional area loss index was used to measure trail impact. This method can provide a basis for long-term monitoring of trail width and depth, and, therefore, trail impact.

In addition, soil parameters were added to our study as suggested by Helgath (1975). Research in other areas had shown that soil properties were related to impact (Bryan 1977). Our hypothesis was that soil parameters would help explain trail impact as well.

METHODOLOGY

The AT within Great Smoky Mountains National Park was surveyed during the summer of 1984 to assess the incidence of trail impact. The trail was sampled at 0.5 km (0.31 mi.) intervals beginning at Fontana Dam and continuing eastward to Davenport Gap on the east boundary of the Park. A measuring wheel was used to locate accurately each point.

A total of 221 sample points were examined. At each sample point the degree of impact was measured using a cross-sectional area loss index (Helgath 1975) (fig. 1). This method provides an objective measurement of impact intensity. Specifically, at each point a taut cord was stretched across the trail at the approximate original surface at the time of construction. Any departure from horizontal was noted using a basic level to correct for the difference. The depth of the trail was then measured to the nearest 0.1 cm (0.04 in.) at 3-cm (1.2 in.) intervals across the trial (fig. 1). From this, the cross-sectional area of removed material was computed. This procedure was repeated 2 m (6.6 ft.) above and 2 m below the sample point. This cross-sectional area loss was the dependent variable used in model construction.

Variables

At each sample point, site characteristics, soil characteristics, and use characteristics were measured. These variables are identified and their measurement methods described below.

Site characteristics.--1. Slope of the trail, 10 m (32.8 ft.) forward and 10 m back as measured to the nearest 1 percent by a clinometer.

2. Slope of the surrounding environment as measured to the nearest 1 percent by a clinometer.
3. Trail aspect (azimuth reading) using a magnetic compass.
4. Aspect of the surrounding environment using a magnetic compass.
5. Elevation using 7-1/2-minute USGS quandrangle maps (40-ft. contour intervals).
6. Evidence of trail construction (side sloping) methods.
7. Width and percent of soil, loose rock, bedrock, and roots on the trail surface.
8. Total width (the sum of soil, loose rock, bedrock, and roots on the trail surface at each sample point).
9. Vegetation type divided into four categories: a. oak-hickory, b. spruce-fir, c. beech gap, d. heath bald.
10. Precipitation amount as estimated in the area by the National Park Service (NPS) and the National Aeronautics and Space Administration (NASA); values used were averages compiled for the period 1935 through 1969.

Soil characteristics.--1. Soil type and soil textural class as determined in the field by feeling the soil with the fingers. There are three soil types: sandy, clayey, and loamy. Only sandy and loamy soil types were identified in the field. The soil texture classes were identified and recorded as either: a. sandy, b. sandy loam, c. silt loam, d. loam. 2. Soil infiltration as measured by an infiltrometer at an undisturbed site adjacent to the sample point. This was done by inserting a metal cylinder, 8 inches long and 7 inches in diameter, 2 inches into the soil. Six ounces of water were then carefully poured onto the soil surface so as not to disturb it. From the instant the water was poured onto the soil, the time that it took for the water to be completely absorbed was recorded to the nearest second.

Use characteristics.--NPS visitor data for campsites (shelters) along the Appalachian Trail were utilized. The use figure was the average amount of visitor use between adjacent shelters for the months of May through September from 1980 to 1984.

RESULTS

Physical Characteristics

The Appalachian Trail (AT) winds some 111 km (68.89 mi.) through Great Smoky Mountains National Park. It follows the divide separating North Carolina and Tennessee for much of that distance. Because it is one of the most popular trails in the East, use is heavy, especially on certain segments.

Vegetation.--Most of the Appalachian Trail is found in the spruce-fir forest type. At lower elevations oak-hickory stands are common. Upper elevation gaps are primarily beech.

Trail tread material.--The trail surface consisted of bare soil, loose rock, bedrock, and roots. The mean of each is shown in table 2.

Table 2.--Trail tread material

Material	cm	Percent
Bare soil	60.7	79
Loose rock	12.7	17
Bedrock	1.7	2
Roots	1.3	2
Total	76.5	100

Slope of trail.--The distribution of the slope or grade of the AT is shown in table 3. The minimum slope encountered was 0 percent; the maximum was 35 percent. The mean slope of the AT within the Park was 10.6 percent.

Table 3.--Distribution of slope by percent

Slope (%)	Percent
0-4	24
5-9	22
10-19	48
Greater than 20	6

According to the NPS Trails Management Handbook (n.d.), grade should not be steeper than 10 percent. At more than one-half of the sample points, however, slope exceeded this standard.

Slope of the environment.--The AT is located on steep sites on, or on either side of, a major divide in the park. Slope ranged from 0 (on the ridge crest) to over 190 percent in one case. The mean slope of the surrounding environment was 37.7 percent.

Elevation.--The AT is a high-elevation trail (for the East) averaging 5,011 feet. The range was 2,000 to 6,640 feet.

Precipitation.--Climate along the Appalachian Trail is cool and moist. Average annual rainfall ranges from 55 to 80 inches.

Cross-sectional Loss Related to Site Characteristics

The Appalachian Trail does exhibit some evidence of impact. The mean cross-sectional area loss was 312.3 cm^2 (48.4 $in.^2$) (standard error 22.35). Average tread depth was 6.4 cm (2.5 in.) (standard error 0.29); average tread width was 76.5 cm (30.1 in.) (standard error 2.06). In Helgath's (1975) assessment of trails in the Selway-Bitterroot Wilderness, the average cross-sectional area loss exceeded 5000 cm^2 (775 $in.^2$); in the Smokies, the highest reading at any point was only 2369 cm^2 (367.2 $in.^2$).

Vegetation type.--Most of the trail is in spruce-fir type. The distribution of sample points by vegetation type is shown in table 4.

Table 4.--Trail impact by vegetation type: means and standard error

Vegetation type		Mean cross-sectional area loss	Mean trail depth	Mean trail width
		- - - (standard error)- - -		
	n	- - - - - - - -cm- - - - - - -		
Oak-hickory	61	297.6	5.8	82.6
		(32.53)	(0.47)	(4.19)
Spruce-fir	105	376.0	7.3	79.3
		(38.09)	(0.44)	(3.18)
Beech gap	53	203.0	5.2	63.2
		(35.62)	(0.45)	(2.53)
Heath bald	2	206.8	5.3	78.0
		(44.50)	(0.20)	(2.24)

Parameters of the trail impacts on each vegetation type in the study are shown in table 4. The largest cross-sectional area loss and trail depth were found in the spruce-fir type; the widest trail width was in the oak-hickory type.

Soil type.--The predominant soil types along the AT are loams and sandy loams. Trail impacts related to soil type are shown in table 5. Sandy loam exhibited the highest impacts in all parameters: cross-sectional area loss, trail depth, and total trail width.

Table 5.--Trail impact as related to soil type: mean and standard error

Soil type		Mean cross-sectional area loss	Mean trail depth	Mean trail width
		- - - (standard error)- - -		
	n	- - - - - - - -cm- - - - - - -		
Sandy	3	178.4	4.3	72.3
		(45.62)	(1.53)	(15.43)
Sandy loam	101	402.5	7.3	84.6
		(43.75)	(0.53)	(3.52)
Silt loam	6	155.8	3.7	65.8
		(48.35)	(0.95)	(8.24)
Loam	111	242.3	5.7	69.7
		(16.44)	(0.29)	(2.29)

Trail condition.--Following Bratton and others (1977) the AT was stratified by trail section for further analysis. A comparison of the most impacted segment with the least impacted segment is shown in table 6. The Newfound Gap-Charlie's Bunion segment is characterized by extreme day use pressure; Buckeye Gap-Silers Bald by almost none.

Table 6.--Comparison of most (Newfound Gap-Charlie's Bunion) and least impacted (Silers Bald-Buckeye Gap) trail segments

	Cross-sectional area loss	Trail depth	Total trail width	Slope
	- -cm^2- -	- - - --cm- - -		-Pct-
Newfound Gap to Charlie's Bunion	605.2	9.3	124.4	9.5
Silers Bald to Buckeye Gap	113.0	2.0	54.3	7.2

The Correlation of Physical Factors and Use to Trail Impact

Correlation coefficients were computed to test for relationships between trail impacts and soil factors, vegetation type, and other site factors. Though soil factors and vegetation type are strongly correlated, they are discussed separately below.

Soil factors.--Correlations between trail factors and soil factors are shown in table 7. The presence of sandy loam or loam soils is significantly correlated to cross-sectional area loss, trail width, trail depth, and the width of the trail in bare soil. Sand and silt-loam soils were not correlated with any trail factors tested.

Soil infiltration rate was positively correlated with trail width in bare soil and negatively correlated with trail width in loose rock. These relationships were significant at the p less than 0.05 level.

Vegetation type.--Trail factors including cross-sectional area loss, trail depth, and trail width in loose rock and bedrock were positively correlated with the presence of the spruce-fir type; trail width in bare soil was negatively related to spruce-fir. The presence of beech gaps was negatively related to cross-sectional area loss, trail depth, total trail width and trail width in loose rock. The presence of oak-hickory was positively related to total trail width and trail width in bare soil (table 8).

Site factors.--Several significant relationships between trail factors and site factors were found (table 9). Cross-sectional area loss was positively correlated with precipitation and slope; trail depth with elevation, precipitation, slope and visitor use. Total trail width was not correlated with site factors.

PREDICTIVE MODEL

An objective of this study was to determine if a predictive model for trail impact could be

Table 7.--Trail factor-soil factor correlations

Trail factors	Soil factors				
	Soil infiltration rate	Sandy loam	Sandy	Loam	Silt loam
Cross-sectional area loss	0.130	0.250*	-0.047	-0.212*	-0.079
Trail depth	.093	.198*	-.057	-.151*	-.104
Total trail width	.141*	.245*	-.016	-.222*	-.058
Width-bare soil	.273*	.223*	-.012	-.223*	.010
Width-loose rock	-.156*	.028	-.002	.013	-.124
Width-bedrock	-.082	.088	.025	-.079	-.046
Width-roots	-.071	.031	-.042	-.052	.096

*$p < 0.05$.

Table 8.--Correlations between vegetation type and trail impact

Trail factors	Vegetation type			
	Spruce-fir	Oak-hickory	Beech gap	Heath bald
Cross-sectional area loss	0.183*	-0.027	-0.185*	-0.002
Trail depth	.209*	-.082	-.154*	-.024
Total trail width	.096	.124	-.243*	.005
Width-bare soil	-.153*	.215*	-.060	.058
Width-loose rock	.372*	-.121	-.293*	-.071
Width-bedrock	.178*	-.084	-.114	-.026
Width-roots	.097	.097	.019	-.034

*$p < 0.05$.

Table 9.--Correlations between trail factors and site factors

Trail factors	Site factors				
	Elevation	Precipitation	Trail slope	Slope of environment	Visitor use
Cross-sectional area loss	0.114	0.197*	0.242*	0.038	0.128
Trail depth	.149*	.221*	.237*	.111	.156*
Total trail width	-.065	.033	.131	.082	.056
Width-bare soil	-.236*	-.045	-.014	-.133	-.048
Width-loose rock	.253*	.073	.232*	.337	.148*
Width-bedrock	.123	.164*	.053	.114	.141*
Width-roots	.056	-.024	.061	.001	-.097

*$p < 0.05$.

created based on soil factors, site factors, and use. Stepwise regression analysis was used to test such parameters for their predictive value. This analysis showed such value to be minimal. Stepwise regression using elevation, vegetation type, soil type, visitor use, precipitation rate, slope of the trail, slope of the environment, and soil infiltration rate was run resulting in an r^2 value for this regression of only 0.145. We conclude, therefore, that the relationships between the parameters tested can be identified, but these relationships are of little value in predicting the quantity of future impact.

The results of this study indicate that managers should respond quickly to evidence of impact on trail segments with loam or sandy loam soils, in spruce-fir forests, and at high elevations. Water bar maintenance is especially important on such sites.

CONCLUSIONS

Results of our analysis show that cross-sectional area loss is related to the presence of loam or sandy loam soils, location in spruce-fir forests or beech gaps, precipitation, and trail slope.

Trail depth was related to the presence of loam or sandy loam soils, location in spruce-fir forests or beech gaps, and elevation, precipitation, trail slope, and visitor use.

Total trail width was related to the presence of loam or sandy loam soils and soil infiltration rate in addition to location in beech gaps.

Bratton and others (1978), in their analysis of the trail system in Great Smoky Mountains National Park, found that trail erosion was

related to vegetation, elevation, and trail slope. We concur with their findings. But, in addition, we find soil type to be related to trail impact, especially at higher elevations.

In the Smokies, visitor use is also highly correlated with elevation (0.744). Therefore, the higher elevation trails like the Appalachian Trail are prime candidates for deterioration. To date, the Appalachian Trail has not seriously deteriorated, especially when compared to areas such as the Selway-Bitterroot Wilderness as reported by Helgath (1975). Continued monitoring can assist in determining if and when restrictions on backcountry use on the AT may be warranted.

The Appalachian Trail was first proposed in 1921 by Benton MacKaye. MacKaye viewed the trail as a piece of wilderness in the urbanized East where "a prize should go to the hiker who traversed the Appalachian Trail in the longest time" (Fox 1984). MacKaye likely did not foresee the time when hundreds of people would use the AT daily as is the case of the 4-mile segment of the Trail between Newfound Gap and Charlie's Bunion. (Day hikers actually use the AT twice; once going and once returning.) The impact of such use is substantial, this particular segment being the most impacted on the AT within the park. Little effort has been made to manage day use in any way, even to count the users. In sum, day hiking is a very popular activity on certain trail segments, and must be considered when determining an appropriate carrying capacity for that trail.

REFERENCES

Bates, G. H. The vegetation of footpaths, sidewalks, carttracks, and gateways. Journal of Ecology. 23: 470-487; 1935.

Bayfield, N. G. Use and deterioration of some Scottish hill paths. Journal of Applied Ecology. 10: 635-644; 1973.

Bratton, S. P; Hickler, M. G.; Graves, J. H. Trail and campsite erosion survey for Great Smoky Mountains National Park - Part I: Introduction and methods. Gatlinburg, TN: U.S. Department of the Interior, National Park Service, Great Smoky Mountains National Park, Uplands Field Research Laboratory; 1977. 61 p.

Bratton, S. P.; Hickler, M. G.; Graves, J. H. Trail erosion patterns in Great Smoky Mountains National Park. Environmental Mangement 3(5): 431-445; 1978.

Bryan, R. B. The influence of soil properties on degradation of mountain hiking trails in Grovesjon. Grografiska Annaler. 59A(1-2): 49-65; 1977.

Cole, D. N. Assessing and monitoring backcountry trail conditions. Research Paper INT-303. Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978. 10 p.

Coleman, R. A. Simple techniques for monitoring footpath erosion in mountain areas of northwest England. Environmental Conservation. 4: 145-148; 1977.

Dale, D.; Weaver, T. Trampling effects on vegetation of the trail corridors of north Rocky Mountain forests. Journal of Applied Ecology. 11: 767-772; 1974.

Fox, S. We want no straddlers. Wilderness. 48(167): 5-19; 1984.

Helgath, S. F. Trail deterioration in the Selway-Bitterroot Wilderness. Research Note INT-193. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1975. 15 p.

Ketchledge, E. H.; Leonard, R. E. Impact of man on the Adirondack high country. Conservationist. 25(2): 14-18; 1970.

Leonard, R. E.; Whitney, A. M. Trail transect: a method for documenting trail changes. Research Paper NE-389. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1977. 8 p.

McQuaid-Cook, J. Effects of hikers and horses on mountain trails. Journal of Environmental Management. 6: 209-212; 1978.

U.S. Department of Interior, National Park Service. Perspectives on maintenance. Grand Canyon, AZ: U.S. Department of the Interior, National Park Service, Albright Training Center; Course lecture in orientation to NPS operations; 1978.

U.S. Department of the Interior, National Park Service. NPS trails management handbook. Denver, CO: U.S. Department of the Interior, National Park Service, Denver Service Center; n.d. 53 p.

Weaver, T.; Dale, D. Trampling effects of hikers, motorcycles and horses in meadows and forests. Journal of Applied Ecology. 15: 451-457; 1978.

Whittaker, P. L. Comparison of surface impact by hiking and horseback riding in the Great Smoky Mountains National Park. Gatlinburg, TN: U.S. Department of Interior, National Park Service, Great Smoky Mountains National Park, Uplands Field Research Laboratory; 1978. 32 p.

Willard, B. E.; Marr, J. W. Effects of human activities on alpine tundra ecosystems in Rocky Mountain National Park. Biological Conservation. 2: 257-265; 1970.

WILDERNESS CAMPSITE IMPACTS: CHANGES OVER TIME

David N. Cole and Jeffrey L. Marion

ABSTRACT: How wilderness campsite impacts change over time was the object of both a 5-year longitudinal study in the Eagle Cap Wilderness, OR, and a cross-sectional study in the Boundary Waters Canoe Area, MN. Conclusions from the two studies generally support each other. The major types of impact that increase substantially after the first few years a site is used are campsite area, tree damage, loss of organic horizons, exposed mineral soil, and perhaps bulk density. Even with these types of impact, most change appears to occur within the first 5 to 10 years after a site is developed. Suggestions for minimizing long-term campsite deterioration are offered.

INTRODUCTION

Wilderness managers must contend with the fact that pronounced impacts are inevitable on campsites that receive more than very low levels of use. In the Eagle Cap Wilderness, OR, for example, even sites used no more than about 5 nights per year had changed substantially. Most of the trees had been injured; most tree seedlings had been eliminated; most vegetation cover had been lost; soils had been compacted resulting in low infiltration rates; and pronounced changes in soil pH, organic matter content, and nutrient content had occurred (Cole 1982). Pronounced impact, even on lightly used campsites, has also been reported in the Mission Mountains Tribal and Rattlesnake Wildernesses, MT (Cole and Fichtler 1983) and the Boundary Waters Canoe Area Wilderness, MN (Frissell and Duncan 1965; Marion and Merriam 1985).

Wherever use levels are moderate to high, impacts will be minimized by concentrating use on a small number of sites (Cole 1981). The use concentration strategy has been implemented by either requiring parties to camp at designated sites or encouraging the use of sites that are already well impacted. In 1980, about 14 percent of wildernesses required use of designated sites, at least in some places; another 13 percent encouraged camping on previously used sites (Washburne and Cole 1983). One of the major concerns with this strategy is that these sites may deteriorate over time, under the pressure of heavy use, to the point where they are seriously degraded and no longer desirable places to camp.

Few data on how campsite conditions change over time are available to evaluate whether continual deterioration is likely to be a problem. In this paper we present data from two separate studies of wilderness campsites. One, undertaken in the Eagle Cap Wilderness, used a longitudinal research design to follow change on 16 long-established campsites over a 5-year period. The other, undertaken in the Boundary Waters Canoe Area, used a cross-sectional approach to compare impacts on 96 campsites in three age classes: 5 to 10 years old, 10 to 13 years old, and more than 13 years old. The relationship between site impacts and age of sites is clarified by the different perspectives that these two methodological designs provide.

PREVIOUS RESEARCH

In 1967, Merriam and his students at the University of Minnesota began a study of changes on newly developed campsites in the Boundary Waters Canoe Area. After 2 years of use, penetration resistance (a measure of compaction using a soil penetrometer) had increased substantially, as had the percentage of trees that were dead or that had exposed roots (Merriam and others 1971). Area of bare soil had not enlarged and the original size of the site had increased an average of about 10 percent. Between the second and fifth years of use, penetration resistance actually declined. Tree mortality and root exposure increased, as did exposure of bare soil. Sites also continued to enlarge; after 5 years they were, on average, over 50 percent larger than when initially developed. From these results, Merriam and others (1973) concluded that impacts generally level off after the first 2 years of use, but site enlargement continues. This conclusion may overlook increases in tree damage and soil exposure that occur beyond the 2-year point.

In 1974 and 1981, 7 and 14 years after original site development, Merriam and his students repeated measurements on a small sample of these sites (Merriam and Smith 1975; Merriam and Peterson 1983). Comparable results are available, over this 14-year period, for only four campsites. Bare soil continued to increase; after 14 years it was about twice as extensive as after 5 years. Both the area without undergrowth and penetration resistance also increased

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over this period, but the magnitude of change was small. Root exposure did not increase, because most trees had exposed roots after just 5 years; but tree mortality continued. Site enlargement also continued, but only on certain sites and not at the rate that occurred between the second and fifth years.

Merriam's conclusion that impacts level off after just 2 years of use supported the results of a study of a newly developed car campground in Pennsylvania (LaPage 1967). In that study, loss of vegetation cover was most pronounced after just 1 year of use. For the next 2 years, cover actually increased, as a few trampling-resistant species became more abundant on the sites. Species diversity continued to decrease for at least 3 years, but continued loss of vegetation was not a problem.

Changes on campsites in the Sylvania Recreation Area, a roadless area in Michigan, were followed over the third and fourth years of campsite use (Legg and Schneider 1977). Litter cover varied seasonally, but appeared to have reached equilibrium levels by the second year of use. Bulk density appeared to approach a maximum after 3 to 4 years. Macropore space was still declining after 4 years, although it was approaching minimal levels on heavy use sites. Depth to the A2 horizon was also still declining after 4 years, although it was already zero on the heavy-use sites. This supports the conclusion that, at least on more heavily used sites, most soil change occurs during the initial years of use.

Two studies have followed change over a 5-year period on long-established car campgrounds. Magill (1970) examined five campgrounds in California; Echelberger (1971) examined nine campgrounds in New York. Magill found a consistent loss of saplings over 5 years, amounting to as much as 24 percent of the saplings on one campground. There was little change in number of seedlings or in number and growth of large trees. Vegetation and litter cover actually increased over the 5 years, although either abnormally high precipitation or establishment of a barrier system to keep cars off the site may have been the cause. Finally the depth of litter decreased over the period. These results led Magill to conclude that campgrounds may be able to adjust to impact rather than be subject to continued deterioration. Echelberger also found little deterioration except for a more than 50 percent loss of trees over 20 feet tall.

On the basis of these studies, the conventional perception of campsite change is that increases in the severity of impact are minimal after the first few years of use; the major ongoing change is site expansion. However, some of these data suggest that other impacts, particularly tree damage and exposure of mineral soil, may also increase over time. Rates of change may not be as great as during the initial break-in period, but they may be sufficient to represent substantial deterioration over the long run. Moreover, only the study in the Boundary Waters Canoe Area examined wilderness campsites. Rates of change on wilderness campsites, where use levels are relatively low, may be quite different from rates in more heavily used areas.

STUDY AREAS AND METHODS

The two studies reported here were undertaken separately. Consequently, study methods are not always comparable. Both studies are included here because they offer the unique opportunity to evaluate change over time from the differing perspectives of a cross-sectional and a longitudinal study. Longitudinal studies evaluate change through repeated measures on the same sites over time. Cross-sectional studies evaluate change by comparing conditions on sites of various ages. The longitudinal approach is preferable to the cross-sectional approach because temporal differences are measured directly. In cross-sectional studies, temporal differences must be inferred from spatial differences that are likely to reflect variables other than campsite age. The advantages of cross-sectional studies are that: (1) they are less time consuming, so sample sizes can be larger; (2) campsites that differ greatly in age can be compared without waiting decades for results; and (3) some impact measurements are so affected by weather conditions that measures of change over time may reflect weather as much as a difference in impact. This is particularly true for soil conditions, such as penetration resistance and infiltration rates.

The Eagle Cap Study

Twenty-two long-established campsites were examined in the Eagle Cap Wilderness, OR, in 1979 (Cole 1982). All were around subalpine lakes at elevations of 7,050 to 7,800 feet. All were located in forests with an overstory primarily of *Abies lasiocarpa* and an understory of *Vaccinium scoparium*. Of these sites, six were closed to use; thus, the analysis of change over time was confined to the 16 sites open to use. Of these, six were low-use sites (with estimated use of less than 5 nights per year), six were moderate-use sites (10 to 20 nights per year), and four were heavy-use sites (25 to 50 nights per year).

Each sample site consisted of both a campsite and an undisturbed control site in the vicinity. The distances from an arbitrarily established center point to the edge of the disturbed campsite and to the first significant amount of vegetation were measured along 16 transects. This defined the camp area and the barren central core (bare area). Tree "seedlings" (0.5 to 4.5 ft tall) were recorded within the camp area, excluding any untrampled "islands"; larger trees were counted within the entire camp area. Trees that had been damaged (that had, for example, trunk scars, nails, or broken branches), that had been felled, or that had exposed roots were counted. In 1984, the center point--a buried

nail--was relocated. Distances to the edge of the disturbed campsite and to the first significant amount of vegetation were remeasured and new camp and bare areas were calculated. The boundaries of the 1979 camp area were laid out again and seedlings, damaged trees, felled trees, and trees with exposed roots were counted as in 1979.

On each campsite, approximately 15 quadrats, 1 m by 1 m square (3.3 by 3.3 ft), were located along four transects, originating at the center point and oriented perpendicular to each other. Percent coverage of total ground vegetation and each plant species, and percent exposed mineral soil were estimated for each quadrat. Coverages were estimated to the nearest percent if under 10 percent or, in 10 percent coverage classes, between 10 and 100 percent. The midpoints of each class were used when calculating mean coverages for the campsite. The thickness of the organic horizons was measured at four points, between 1 and 2 m (3.3 and 6.5 ft) from the center point, along each transect. In 1984, nails at the end of each transect were relocated. This permitted precise relocation of the transects and quadrats. Coverages were estimated and organic horizon thickness was measured as in 1979.

On the control plots, which varied in size between 980 and 2,164 ft^2, percent coverage of total ground vegetation and each plant species, and percent exposed mineral soil were estimated for the entire plot. Seedlings were counted on a 50-m^2 (538-ft^2) subplot placed in the center of the control. Organic horizon thickness was measured at four regularly distributed points. Measurements were repeated in 1984.

The amount of change that had occurred on campsites prior to 1979 was inferred from comparisons of campsites and controls. Absolute difference is the campsite measure minus the control measure. Change in species composition was estimated by comparing the composition of campsites and controls, using the following coefficient of floristic dissimilarity:

$$Fd = 0.5 \Sigma \left|p_1 - p_2\right|$$

where p_1 is the relative cover of a given species on the control site and p_2 is the relative cover of the same species on the campsite.

The magnitude of change between 1979 and 1984 was expressed as the median difference between 1979 and 1984 values. Where appropriate, change in both campsite measures and absolute differences (the campsite-control comparison) was used. The statistical significance of these changes (the extent to which the changes measured on these sample sites are applicable to all sites in the area) was evaluated with the Wilcoxon matched-pairs, signed-ranks test. This nonparametric test was selected because data for many variables were not normally distributed and the sample size was small. Differences between 1979 and 1984 were considered significant if probability values were 0.05 or less.

The Boundary Waters Canoe Area Study

In the Boundary Waters Canoe Area, MN, 96 lakeside campsites were examined. These sites were located in a variety of forested plant communities. Twenty-eight sites were low use (estimated use of less than 12 nights per year), 38 were moderate use (20 to 40 nights per year) and 32 were high use (more than 60 nights per year). Sites were also classified according to their age. Twenty-two sites were 5 to 10 years old, 34 were 11 to 13 years old, and 36 were more than 13 years old. Sites in the oldest category were user created; the younger sites were developed by the Forest Service.

Each study site consisted of both a campsite and a control. Camp area was measured with steel tapes. Seedlings and larger trees were counted on this area. Larger trees were classified as to severity of tree damage and root exposure. These classifications were used to derive indexes of tree damage and root exposure. Each index could vary between 1 (no damaged trees) and 4 (all trees with severe damage). Refer to Marion (1984) for more detail. Seedlings were also counted on the 50-m^2 (538-ft^2) control plots.

For the campsite as a whole, and for the control site, percentages of dense vegetation, litter, exposed mineral soil, exposed rock, exposed root area, and each individual species were estimated. Dense and sparse vegetation were combined for an estimate of total vegetation cover. Four soil samples were also taken, below the organic horizons, both on campsites and controls. The irregular hole method for determining bulk density was used due to the large proportion of coarse fragments in the soil (Howard and Singer 1981). Soil samples were analyzed for moisture content, stone-free bulk density, and organic content. Organic horizon thickness and penetration resistance (measured with a pocket soil penetrometer) were measured at 12 points, both on the campsite and the control.

As in the Eagle Cap study, absolute difference was used to infer amount of change. An overall impact scale was constructed using standardized measures of eight impact variables: root exposure index, tree damage index, floristic dissimilarity, camp area, and absolute differences for bare mineral soil, dense vegetation cover, bulk density, and organic horizon thickness.

The relationship between these impact parameters and campsite age was examined through two-way analyses of variance, with age and use level as independent variables. This approach was necessary because use level and age were correlated and there was often a significant relationship between impact and use level. Differences between age categories were considered significant

if probability values were 0.05 or less. Through multiple classification analysis, means for each age class are presented, after being adjusted for use level effects.

RESULTS AND DISCUSSION

The Eagle Cap Wilderness Study

Between 1979 and 1984, campsite area increased on 14 of the 16 sites. The median increase was 237 ft^2 (table 1). This represents an 11 percent increase in area above the median camp area in 1979. The largest increase was over 1,600 ft^2, an increase of three and one-half times. This was one of the few variables for which differences between 1979 and 1984 were statistically significant. This result confirms the finding of Merriam's studies that site enlargement is a consistent long-term change on campsites. Bare area (the central area devoid of vegetation) increased on 10 sites. The median increase was 54 ft^2, a 10 percent increase from the 1979 bare area. The largest increase was 775 ft^2, a 124 percent increase; the largest decrease was 194 ft^2, a 33 percent decrease. Again this is comparable to findings in Merriam's studies. Increases in both camp area and bare area are general trends. The camp area increases are more pronounced and also more consistent.

Changes in tree damage were inconsistent. The number of damaged trees increased on three sites, decreased on six sites, and was unchanged on seven sites. The median number of damaged trees declined slightly between 1979 and 1984. Declines in number of damaged trees were usually the result of tree felling. The number of felled trees increased on half of the sites. The most extreme example was one site where the number of felled trees increased from 8 to 19. Inexplicably, the number of felled trees decreased on three sites. The number of trees with exposed roots increased on four sites and decreased on three sites; the median change was zero. These results suggest that yearly increases in tree damage are typically very small, although they can be substantial on some sites. This is quite different from the results of Merriam's studies. Shallow soil on campsites in the Boundary Waters Canoe Area makes root exposure and tree mortality unusually prevalent.

Vegetation cover increased on nine sites and decreased on six sites. The largest increase in cover was 9 percent; the largest decrease was 7 percent. The median increase was only 0.3 percent. Vegetation cover increased even more on controls. Consequently, absolute differences became more negative over this time period. In 1984, the median campsite had 46 percent less vegetation than its paired control, compared to a median difference of 45 percent in 1979. This represents a median increase in vegetation loss of 1.5 percent. The difference in species composition between campsites and controls (floristic dissimilarity) increased on 10 sites. Increases were generally small, with a median change of just 2 percent. These findings agree

Table 1.--Change in impact on 16 campsites in Eagle Cap Wilderness between 1979 and 1984[1]

Impact parameter	Campsite 1979	Campsite 1984	Campsite Change	Campsite p	Absolute difference 1979	Absolute difference 1984	Absolute difference Change	Absolute difference p
	Median				Median			
Camp area (ft^2)	2,131	2,508	237	0.001				
Bare area (ft^2)	915	1,119	54	0.03				
Mutilated trees (#)	9.0	7.5	0	0.17				
Felled trees (#)	4.0	5.0	1.0	0.08				
Trees with exposed roots (#)	3.5	3.5	0	0.26				
Floristic dissimilarity (%)	50	50	2	0.17				
Seedlings (#/acre)	110	122	1	0.35	-813	-787	-90	0.03
Vegetation cover (%)	7.2	7.5	0.3	0.20	-45.3	-46.2	-1.5	0.27
Exposed mineral soil (%)	24.3	42.0	4.8	0.06	16.5	29.0	5.1	0.07
Organic horizon thickness (in)	0.10	0.04	0	0.30	0.10	0.12	0	0.39

[1]p values refer to Wilcoxon matched-pairs, signed-ranks tests between 1979 and 1984 values. Absolute differences are control values minus campsite values.

with those of Magill who found no continued vegetation deterioration on long-established campsites.

As with vegetation cover, the number of seedlings on campsites generally increased between 1979 and 1984. Seedlings increased on eight sites and decreased on four sites. However, the median increase was only one seedling per acre. The number of seedlings on controls decreased over this period. Consequently, absolute differences changed more dramatically. The median difference between campsites and controls decreased 90 seedlings per acre. This reduction in seedling loss is statistically significant. Even in 1984, however, over 90 percent of the seedlings have been eliminated from campsites. Seedlings are reduced to very low levels by initial use; thereafter the number of seedlings probably fluctuates around these low values. Seedlings that survive initial use are likely to survive prolonged use.

Amount of exposed mineral soil increased on 12 sites. The largest increase was 34 percent. Although this increase is not quite statistically significant, the magnitude and consistency of this increase suggests it is a general trend that would probably have been statistically significant with a larger sample size. Between 1979 and 1984, the number of sites with more than 50 percent mineral soil increased from five to eight. This represents a substantial increase in impact that is somewhat disguised by the low median increase of only 5 percent. Mineral soil exposure on controls changed very little, so estimates of change based on absolute difference were comparable to those based on campsite conditions. Again this confirms the finding of Merriam's studies that area of bare soil usually continues to increase over time. The thickness of organic horizons increased on six sites and decreased on seven sites. The median change was zero. The number of samples and measurement techniques used were probably insufficient to reveal the small changes occurring. Moreover, samples were taken close to the center of the site where one might expect most change to have occurred prior to 1979. Median values for campsites in 1979 and 1984 suggest that slight reductions in thickness may be ongoing even close to the center of the site. The fact that exposed soil is increasing, for the entire campsite, suggests that thickness is being reduced more dramatically further from the center.

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The impacts for which there are statistically significant increases on older campsites are tree damage, increase in amount of bare mineral soil and bulk density, and decrease in organic horizon thickness. These differences are sufficient to make the relationship between impact scale and age significant (table 2). For most of these impact parameters the difference between 5- to 10-year-old and 11- to 13-year-old sites is minor compared with the difference between these younger sites and the sites that are over 13 years old. However, the largest difference is always the difference between controls and the 5- to 10-year-old sites.

Greater tree damage on older sites was expected because such damage is cumulative over time. Once a tree is damaged, it is damaged for life. The relationship between tree damage and age is more pronounced here than on Eagle Cap sites, probably because a longer time period was examined in this cross-sectional study. New tree damage must occur relatively infrequently; consequently, changes over just 5 years are relatively small on most sites. The increase in mineral soil also supports the Eagle Cap results. Absolute difference is identical to campsite coverage because exposed mineral soil is not found on controls.

Increase in bulk density is significantly related to age, but campsite bulk density is not. Neither campsite penetration resistance nor increase in penetration resistance is significantly related to age. All of these impact parameters do exhibit a tendency to increase with age, however.

Increase in bulk density is significantly related to age, but increase in penetration resistance is not. In contrast, penetration resistance is significantly related to use level but bulk density is not. The difficulty of interpreting these results illustrates the problem with relying exclusively on cross-sectional studies. For both variables, differences between sites in different age classes are much more pronounced on more lightly used campsites, and differences between sites in different use level classes are more pronounced on younger sites. This suggests that compaction tends to level off both with increasing use and age. Theoretically this makes sense, because there is a limit to the pressure recreational use can exert on soil. This places a limit on compaction levels--a limit that is likely to be reached before too many years of use. Thinner organic horizons on older sites are likely to increase susceptibility to compaction. This may explain the more pronounced increases in bulk density on older sites.

Organic horizons are thinner on older sites, but absolute loss of organic horizons (the campsite-control comparison) is no greater. Again this is difficult to explain other than to suggest that controls did not provide sufficiently accurate measures of conditions prior to use. The thinner horizons and more pronounced increase in exposed mineral soil on older sites strongly suggest that net loss of organic horizons continues on campsites.

It is interesting to note that one-way analyses of variance also showed significant relationships between campsite age and both camp area and root exposure. However, the significance of

Table 2.--Relation between age and amount of impact on 96 campsites in the Boundary Waters Canoe Area[1]

Impact parameter	Campsite age (years)						p
	5-10	11-13	>13	5-10	11-13	>13	
	- Unadjusted means - -			- - Adjusted means - -			
Camp area (ft^2)	1,888	1,920	3,109	2,396	2,339	2,403	0.92
Root exposure index	2.48	2.44	2.75	2.50	2.46	2.71	0.26
Tree damage index	2.64	2.73	3.07	2.67	2.76	3.03	0.05
Bare mineral soil (%)	7	6	17	9	8	14	0.05
Seedlings							
campsite (#/acre)	161	155	68	129	125	116	0.98
absolute difference (#/acre)	-1,236	-726	-1,116	-1,315	-811	-984	0.17
Vegetation cover							
campsite (%)	38	45	25	33	41	32	0.28
absolute difference (%)	-57	-51	-66	-60	-53	-61	0.43
Bulk density							
campsite (g/cc)	1.21	1.32	1.37	1.22	1.34	1.34	0.19
absolute difference (g/cc)	0.14	0.26	0.36	0.14	0.27	0.36	0.002
Penetration resistance							
campsite (ton/ft^2)	3.2	3.6	4.2	3.5	3.8	3.8	0.17
absolute difference (ton/ft^2)	2.0	2.2	2.9	2.2	2.3	2.6	0.13
Organic horizon thickness							
campsite (in)	1.1	0.9	0.4	1.0	0.8	0.6	0.01
absolute difference (in)	-1.4	-1.3	-1.7	-1.5	-1.4	-1.5	0.60
Soil organic content							
campsite (%)	6.2	5.8	6.7	6.5	6.1	6.2	0.89
absolute difference (%)	0.9	0.5	0.7	1.2	0.7	0.4	0.52
Impact scale	-0.32	-0.24	0.41	-0.17	-0.12	0.21	0.002

[1]p values are taken from two-way analyses of variance. Adjusted values are means after using multiple classification analysis to take differences in use level into account. Absolute differences are control values minus campsite values.

these two relationships disappears when differences related to use level are accounted for. The adjusted means for root exposure do show an increase in exposure with age; apparently site-to-site variability is simply too high for these differences to be statistically significant.

Camp area, for any given use level, is simply not any larger on old than on young campsites. This is surprising in light of the finding, from longitudinal studies, that a major ongoing change on campsites is an increase in area. Merriam and Peterson (1983) showed that campsite enlargement on Boundary Waters Canoe Area campsites continues for at least 14 years, although the rate of increase decreases over time. The tendency for sites to expand over time may have been negated by the imposition of a party size limit of 10 persons, in 1975, and a campsite maintenance program that actively attempts to limit expansion.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

These two studies contribute a more detailed view of how impacts on wilderness campsites change over time. In the forested environments examined, the most sizable changes that continue beyond the break-in period appear to be site expansion (in the absence of stringent limits on party size) and loss of organic matter. Tree damage is also cumulative, but most damage occurs shortly after sites are developed and yearly increases thereafter are generally quite small. Nevertheless, because recovery from damage is minimal, cumulative effects over time can be large, particularly on certain campsites. There is also some indication that soil compaction increases over time. This may reflect increasing compaction on campsites as organic horizons are removed. Organic horizons tend to cushion soil from trampling pressure and inhibit compaction. Ground-level vegetation--tree seedlings, shrubs, and herbaceous vegetation--

appears to equilibrate at low cover levels after several years. This seems to be the case despite small increases over time in the size of the barren core of campsites. Change in species composition also appears to stabilize. Changes occur but they tend to fluctuate around equilibrium conditions.

The implication of these findings, at least in the areas studied, is that managers should expect continued deterioration of campsites over time. Highest levels of impact usually occur on the oldest and most frequently used sites. Site expansion, tree damage, and loss of organic horizons are likely to be the impacts that intensify most over time. However, even these impacts occur most rapidly during the first few years a campsite is used. Therefore the option of rotating sites is likely to be self-defeating except where use levels are low.

There are a number of ways of mitigating these impacts on designated sites or wherever long-term use occurs. Educating visitors about the problems of cumulative impact is an important first step. This is really the only means of avoiding tree damage. It can also reduce the likelihood of campers unnecessarily expanding the site. Expansion can also be controlled through limitations on party size, careful selection of campsite locations, and proper design and layout of campsites. Of these options, limiting party size is the obvious first choice and the only viable choice where use is widely dispersed and visitors are allowed to camp wherever they want. Maximum party sizes will have to be less than the current common limits of 15 or 25 before this is likely to be effective. Where sites are designated, they can be located in thick vegetation and rough topography, where visitors will be unlikely to utilize offsite areas. Areas with poor drainage or any other condition likely to encourage offsite use should be avoided. Improvement of onsite tent pads will also encourage onsite use. Finally, large rocks, logs, and trees can be used to close off places where site enlargement is occurring.

Avoiding problems resulting from loss of organic matter is more difficult. Perhaps the best solution is locating sites in forests with naturally thick organic horizons. This would minimize exposure of mineral soil and soil compaction.

Campsite impacts are inevitable wherever use occurs. In situations where use levels are moderate to high, there is little option but to concentrate use on carefully selected sites that will remain functional and desirable for a long time. While such a strategy avoids the problem of a proliferation of substantially impacted sites, it creates the problem of how to maintain conditions on a small number of heavily used and impacted sites. This problem is similar in many ways to maintenance of campgrounds outside of wilderness. Certain types of impact are cumulative and/or tend to intensify over time. Recognizing which problems do increase over time should improve the ability of managers to counter these tendencies.

REFERENCES

Cole, David N. Managing ecological impacts at wilderness campsites: an evaluation of techniques. Journal of Forestry. 79: 86-89; 1981.

Cole, David N. Wilderness campsite impacts: effect of amount of use. Research Paper INT-284. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 34 p.

Cole, David N.; Fichtler, Richard K. Campsite impact on three western wilderness areas. Environmental Management. 7: 275-288; 1983.

Echelberger, Herbert E. Vegetative changes at Adirondack campgrounds--1964 to 1969. Research Note NE-142. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1971. 8 p.

Frissell, Sidney S., Jr.; Duncan, Donald P. Campsite preference and deterioration in the Quetico-Superior canoe country. Journal of Forestry. 63: 256-260; 1965.

Howard, R. F.; Singer, M. J. Measuring forest soil bulk density using the irregular hole, paraffin clod, and air permeability. Forest Science. 27: 316-322; 1981.

LaPage, Wilbur F. Some observations on campground trampling and groundcover response. Research Paper NE-68. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1967. 11 p.

Legg, Michael H.; Schneider, Gary. Soil deterioration on campsites: northern forest types. Soil Science Society of America Journal. 41: 437-441; 1977.

Magill, Arthur W. Five California campgrounds... conditions improve after 5 years' recreational use. Research Paper PSW-62. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1970. 18 p.

Marion, Jeffrey L. Ecological changes resulting from recreational use: a study of backcountry campsites in the Boundary Waters Canoe Area Wilderness, Minnesota. St. Paul, MN: University of Minnesota; 1984. 279 p. Ph.D. dissertation.

Marion, Jeffrey L.; Merriam, L. C. Recreational impacts on well-established campsites in the Boundary Waters Canoe Area Wilderness. Station Bulletin AD-SB-2502. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1985. 16 p.

Merriam, L. C.; Peterson, R. F. Impact of 15 years of use on some campsites in the Boundary Waters Canoe Area. Research Note 282. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1983. 3 p.

Merriam, L. C., Jr.; Smith, C. K. Newly established campsites in the Boundary Waters Canoe Area: restudy of selected sites - 1974. Research Note 254. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1975. 4 p.

Merriam, L. C., Jr.; Goeckermann, Kent; Bloemendal, J. A.; Costello, T. M. A progress report on the condition of newly established campsites in the Boundary Waters Canoe Area. Research Note 232. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1971. 4 p.

Merriam, L. C., Jr.; Smith, C. K.; Miller, D. E.; and others. Newly developed campsites in the Boundary Waters Canoe Area: a study of 5 years' use. Station Bulletin 511, Forestry Series 14. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1973. 27 p.

Washburne, Randel F.; Cole, David N. Problems and practices in wilderness management: a survey of managers. Research Paper INT-304. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 56 p.

VARIATION OF VEGETATION AND SOIL CHARACTERISTICS WITHIN WILDERNESS CAMPSITES

Thomas J. Stohlgren

ABSTRACT: Field studies in Sequoia National Park California, indicate that the degree of impact to vegetation and soils varies considerably within campsites. The central areas of campsites, where trampling is concentrated, show lower plant species diversity, more highly compacted soils and lower soil nutrient concentrations than do peripheral areas of the same campsites.

INTRODUCTION

Recreational use of wilderness areas results in disturbance of vegetation and soils associated with trails and campsites (Bratton and others 1978; Cole 1982). Effective wilderness management requires an accurate assessment of these impacts (Parsons and MacLeod 1980), and an understanding of an area's ecological characteristics such as the susceptibility to trampling (Cole 1978) and the potential for recovery, or resiliency, of vegetation and soils following disturbance (Stohlgren 1982). In this paper I discuss the variation of vegetation and soil characteristics within wilderness campsites and propose a methodology to accurately evaluate impact in the most heavily used areas of a campsite relative to moderately trampled or untrampled areas on the periphery of the campsite.

Several systems have been developed to record the extent of visitor impact on wilderness areas. Hendee and others (1976) developed the Code-A-Site system which is well suited for wilderness areas with relatively few, well defined campsites. This system was modified by Schreiner and Moorhead (1979) to inventory campsites in Olympic National Park. Frissell (1973) and Parsons and MacLeod (1980) developed methods for rating campsite condition classes based on visual estimates of impact to understory vegetation, litter and duff, and trees. The latter method was successfully used to inventory the extent of impact in numerous (> 8000), widely scattered campsites in Sequoia and Kings Canyon. Still, only limited, quantitative information on vegetation and soils impact is gained from campsite inventories such as these.

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There have been several attempts to gather more detailed information on campsite impact. Previous studies have consistently documented loss of vegetation cover and decreased plant species diversity (LaPage 1967; Dykema 1971; Cole 1977; Fichtler 1980) as well as increased soil compaction (Dotzenko and others 1967; Settergren and Cole 1970; Young and Gilmore 1976; Cole 1982) in campsites relative to control sites. Soil chemistry in campsites can be highly variable. In Illinois, Young and Gilmore (1976) found increases in soil Ca, K, P, N, and pH in campsites relative to control areas. Other studies have shown variable responses of N as well as major cations (Rutherford and Scott 1979; Cole 1982). Several investigators have reported decreased levels of soil organic matter in campsites (Dotzenko and others 1967; Settergren and Cole 1970; Dawson and others 1978) while others have reported increased levels (Young and Gilmore 1976; Monti and Mackintosh 1979; Cole 1982).

Comparisons and generalizations of the effects of trampling on vegetation and soils in campsites are difficult due to different "site factors" (e.g., vegetation type, soil characteristics and microclimate), and "visitor use factors" (e.g., number, seasonality, duration and behavior of users in the past). Vegetation and soil types, for example, may differ widely in susceptibility to trampling (Cole 1978) and in potential to recover once use has ceased (Parsons and DeBenedetti 1979; Ranz 1979; Stohlgren 1982).

Results of studies on the effects of amount of use on wilderness campsites relative to control sites have been highly variable (Young and Gilmore 1976; Cole 1982). This may be due, in part, because visitor use factors not only differ between campsites but also within campsites. In Yosemite National Park, California, Holmes and Dobson (1976) commonly observed "barren core" areas, resulting from concentrated trampling, in the center of many campsites. These areas were generally surrounded by an area of less trampled vegetation and less compacted soils. Similar barren core areas, nearly devoid of vegetation, were observed in campsites throughout Sequoia and Kings Canyon National Parks (unpublished data), and several other western wilderness areas (Cole 1977, 1983; Schreiner and Moorhead 1979; Dykema 1971). Approaches to sampling vegetation on soils along the use/impact gradient within campsites depend on specific study objectives. When comparing campsites varying in use intensities to

control areas, many researchers lumped vegetation and/or soils data from transects radiating from the campsite center (Dykema 1971; Cole 1977, 1983; Bratton and others 1978). This type of approach may underestimate the impacts in the most heavily trampled, barren core areas of the campsites. If the objective is to provide managers with accurate information on the maximum extent and severity of visitor impacts, a stratified random sampling approach should be used. Easterbrook (1968), Mackintosh (1979), Hingston (1982) and Stohlgren (1982) have suggested stratifying impact zones within campsites prior to vegetation and soil sampling, to separately analyze impacts in barren core areas relative to moderately trampled areas of the campsites. They hoped to reduce the variability in reported results and quantify the maximum impacts to vegetation and soils due to campsite use. This approach was used here.

STUDY AREA AND METHODS

Emerald Lake and Pear Lake are located at elevations of 9,197 ft. (2,804 m) and 9,510 ft. (2,899 m), respectively, in adjacent granitic subalpine basins in Sequoia National Park, in the southern Sierra Nevada of California. The vegetation surrounding the lakes is characterized by lodgepole pine (Pinus contorta ssp. murrayana), willow (Salix sp.), and a sparse understory of graminoids and herbs.

Two campsites at Emerald Lake and one at Pear Lake were closed to visitor use in October 1978. Within each campsite a 32.8 ft. x 32.8 ft. (10 m x 10 m) study area was selected along compass directions, and stakes placed around the perimeter at 3.28 ft (1 m) intervals. This area was divided into a grid of 10.76 ft^2 (1 m^2) sections with twine. Each 2.69 ft^2 (0.25 m^2) quarter of each 10.76 ft^2 section was subjectively stratified as core, intermediate or periphery based on visual criteria (figure 1). Core plots were generally in the center of the site and showed nearly complete elimination of above ground vegetation, removal or pulverization of litter and duff layers, and continuous disturbance of surface soil. Intermediate plots showed notable but less substantial impact, and were commonly located between core and periphery areas of campsites. These plots showed more vegetation cover, less litter and duff pulverization, and contained pockets of intact surface sod. Periphery plots appeared as unimpacted or unrecognizably impacted areas that bordered the campsites. All 2.69 ft^2 (0.25 m^2) plots were numbered and pooled by impact stratum and by campsite. Plots incorporating more than one impact strata were excluded from future sampling.

A subsample of five to ten 2.69 ft^2 plots were randomly selected to characterize vegetation in each impact strata at each site. Foliar cover by plant species was estimated to the nearest five percent (to the nearest one percent where cover was less than five percent). Soil bulk density was determined for the top 2 inches (5 cm) of soil (Blake 1965) from additional sets of five to ten 2.69 ft^2 (0.25 m^2) plots randomly drawn from each strata at each site.

Forty five bulk density samples (five in each strata at each of the three campsites) were collected and used for soil particle size and texture analysis as outlined by Bouyoucos (1926). Ten 0.044 lb. (20 g) scoops (0-5 cm in depth) of soil were collected from each strata at each campsite and pooled by strata in the summer of 1979 for baseline chemical analyses. A Technicon Auto-Analyzer and Atomic Absorption Spectrometer were used for analysis of N, P, K, Ca, and Mg (Schuman and others 1973, Perkin-Elmer Company 1976, Isaac and Johnson 1976). Percent loss on ignition (percent organic matter) and pH were also analyzed. Soil moisture of a typical mid-summer day was sampled between 12:00 and 14:00 on August 20,1979. Eighteen (two in each strata at each campsite) air-tight, cylindrical soil cans were filled from 2 in. deep by 2 in. diameter holes, and analyzed according to Peters (1965). These data provide both a spatial comparison between strata and a baseline measurement against which future changes might be compared.

Analysis of variance and Newman-Keuls multiple range tests were used to evaluate significant differences between campsites and the three impact strata for foliar cover, mean number of species per plot, soil bulk density and soil moisture. When the core and intermediate strata plots were lumped and analyzed relative to periphery plots, Student's t-test was used. No tests for significance were possible for pooled soil chemical samples.

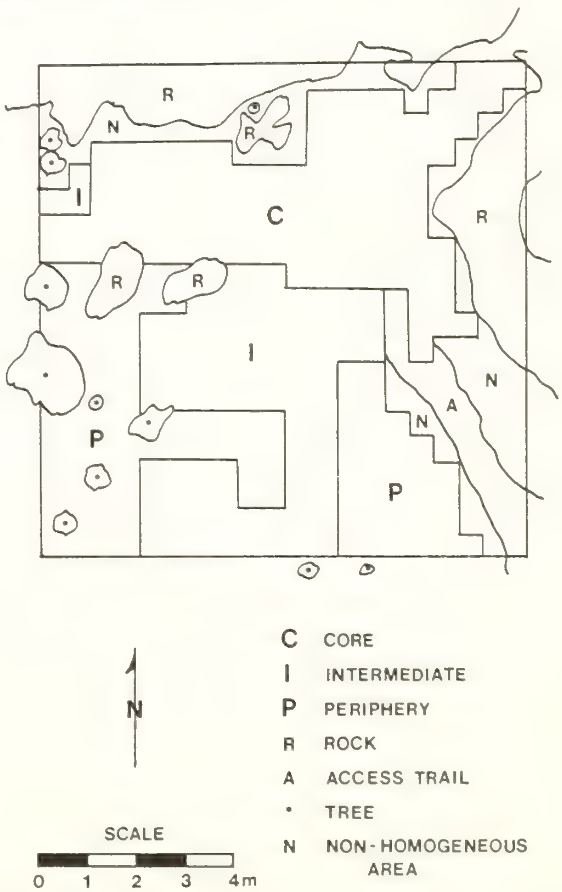

Figure 1.--Example of a detailed base map of one of the campsites closed to visitor use.

RESULTS AND DISCUSSION

Barren core plots showed significantly lower foliar cover than intermediate and periphery areas of the same campsites (table 1). I recognize this is due to the subjective stratification of campsite areas prior to vegetation sampling. One objective, however, was to quantify the ecological impacts associated with "visual" criteria often used to evaluate campsite condition (Frissel 1973; Cole 1983; Parsons and MacLeod 1980). I also found barren core areas to have significantly fewer plant species, significantly higher soil compaction, and lower levels of N, K, Mg, Ca and organic matter than intermediate and periphery areas of the same campsites (table 1). Soil moisture, though measured for only one point time, was also significantly lower in the core stratum. No difference in soil texture between strata was evident, and pH was only slightly higher in the core relative to the intermediate and periphery strata.

The intermediate impact strata assumed to have received moderate levels of trampling over many years, showed moderately high foliar cover and number of plant species while not having significantly higher soil compaction relative to periphery areas of the same campsites. They were most like the heavily trampled core stratum in concentration of soil macronutrients, percent organic matter and soil moisture content. I speculate that while moderately trampled areas retain tufts of vegetation and surface sod necessary to significantly buffer soil compaction, increased leaching of macronutrients and loss of soil organic matter may still occur. Once tufts of vegetation are removed and barren core areas

Table 1.--Pre-closure variation of selected vegetation and soil characteristics between campsite impact strata. Macronutrients, pH, percent loss on ignition were pooled samples. The mean and standard error (in parentheses) are presented for non-pooled samples

Characteristic	Core	Impact strata intermediate	Periphery
VEGETATION			
Foliar cover(%)	1.09 (0.39) a,b	15.29 (1.93) a	24.79 (3.39) b
(n)	(32)	(24)	(19)
# of species per 2.69 ft^2 plot	0.56 (0.14) a,b	2.38 (0.22) a	3.47 (0.40) b
(n)	(32)	(24)	(19)
SOIL			
Bulk density (lb/in^2)	0.048 (0.001) a,b	0.025 (0.003) a	0.018 (0.002) b
(n)	(16)	(16)	(17)
Soil texture (n=15)			
Sand %	85.2 (1.5)	83.6 (0.9)	84.8 (1.7)
Silt %	12.3 (1.4)	13.8 (0.8)	11.9 (1.6)
Clay %	2.5 (0.3)	2.7 (0.3)	3.2 (0.3)
Macronutrients			
N(ppm)	28.6	40.4	74.8
P(ppm)	47.9	28.1	56.4
K(ppm)	50.3	65.2	107.2
Mg(ppm)	7.2	11.4	37.6
Ca(ppm)	108.8	181.0	967.3
pH	3.70	3.55	3.52
% loss on ignition	6.36	15.43	29.62
% Soil Moisture (n=6)	13.8 (4.7) c	28.2 (2.1)	33.8 (1.9)

a,b significantly different at $p<0.001$
c significantly different at $p<0.05$

created, soil compaction significantly increases while soil macronutrient concentrations, percent organic matter, and moisture decrease even further.

The variability in vegetation and soil characteristics found within campsites emphasizes the difficulty in utilizing lumped data for campsite impact studies. Combined core and intermediate data from the various vegetation and soil characteristics shown in table 1 would have drastically underestimated the severity of the impacts to the central areas of these campsites (table 2). "Averaged" values of percent foliar cover and number of species for an entire campsite do not provide the manager with a realistic evaluation of the effects of concentrated trampling on specific vegetation types. The 7.35 percent cover reported from lumped data only represents a 70 percent decrease from levels found in the periphery of the campsites. Concentrated trampling in this lodgepole pine forest type might actuallv show a 96 percent decrease in understory cover (table 1) in the heavily trampled areas within a campsite. Lumped soil bulk density data might be even more misleading to wilderness managers. Combined core and intermediate data (table 2) proved statistically different from periphery areas but presenting the data in this way masks the potential ecological significance of severely compacted soils. Bulk densities of 0.047 $lb./in.^2$ (1.3 g/cc), like those reported in the barren core plot may be harmful to the development of forest understory plants (Bratton and others 1966; Minore and others 1969).

Understanding the variability of vegetation and soil characteristics may also provide managers with a more realistic evaluation of potential for recovery, should use be halted. Areas devoid of vegetation and with highly compacted soils, such as the barren core areas in our study sites, may take decades longer to recover than moderately trampled areas (Stohlgren 1982). Low nutrients, organic matter and high moisture stress may hinder grass and herb seedling establishment in such areas. Conversely, moderately trampled areas retained tufts of vegetation and enough surface sod to promote more rapid vegetative recovery over a three year period. Thus, the time necessary for the total recovery of campsites such as these may depend primarily on the extent of barren core, soil compaction and the soil chemistry of those areas.

MANAGEMENT IMPLICATIONS

There is a certain amount of subjectivity when delineating campsite or use strata boundaries due to the gradient of impacts found extending from campsite centers. This cannot be entirely avoided but can be partially mitigated by analyzing the impacts in barren core areas separately from the moderately and untrampled areas of the campsites. Stratifying campsites prior to vegetation and soil sampling appears to be an important first step in evaluating the severity of campsite impacts.

Managers must ultimately decide what "limits of acceptable change" will be allowed (Frissell and Stankey 1972). For campsites, the "acceptable limits" of vegetation and soil impacts should be based both on the susceptibility of particular vegetation and soil types to concentrated trampling, and the ability of the most severely impacted areas of the campsites to recover.

Light levels of recurring use probably maintain barren core areas. This would maintain high soil compaction by counteracting natural decompacting mechanisms (i.e., freeze-thaw action), and

Table 2.--Mean and standard error (in parentheses) for lumped data from core and intermediate plots compared to periphery plots. A Student t-test was used to compute statistical difference

Characteristic	Impact Strata: Core Intermediate Plots Combined	Periphery
Foliar cover (%)	7.35 (1.27)	25.26 (3.39) a
(n)	(56)	(19)
Number species per $2.69\ ft^2$ plot	1.48 (0.19)	3.47 (0.40) b
(n)	(56)	(19)
Soil bulk density (lb/in^2)	0.036 (0.003)	0.018 (0.002) a
(n)	(32)	(17)

a = significantly different from core and intermediate at $p < .001$
b = significantly different from core and intermediate at $p < .01$

threaten seedling establishment and revegetation of barren core areas. In Sequoia and Kings Canyon National Parks, we advise wilderness travelers to use already impacted campsites rather than create new barren core areas in pristine areas. In this way, the total area of severely impacted vegetation and soils is kept from increasing.

REFERENCES

Blake, G. R. Bulk density. In: Black, C. A. ed. Methods of soil analysis, Part 1. Amer. Soc. Agron., Inc. 1965. 374-380.

Boyoucos, G.J. Estimation of the colloidal material in soils. Science 64:362; 1926.

Bratton, H.; McCully, W. G.; Taylor, U M.; Box, J. E. Jr. Influence of soil compaction on emergence and first-year growth of seeded grasses. J. Range Manage. 19:118-121; 1966.

Bratton, Susan Power; Hinckler, Mathew, G.; Graves, James H. Visitor impact on backcountry campsites in the Great Smoky Mountains. Environ. Manage. 2:431-442; 1978.

Cole, David N. Man's impact on wilderness vegetation: an example from Eagle Cap Wilderness, northeastern Oregon. Eugene, OR: Univ. of Oregon; 1977. 307 p. Ph.D. dissertation.

Cole, David N. Estimating the susceptibility of wildland vegetation to trailside alteration. J. Appl. Ecol. 15:281-286; 1978.

Cole, David N. Wilderness campsite impacts: effect of amount of use. Res. Pap. INT-284. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 34 p.

Cole, David N. Monitoring the conditions of wilderness campsites. Res. Pap. INT-302. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 10 p.

Cole, David N; Dalle-Molle, John. Managing campfire impacts in the backcountry. Res. Pap. INT-135. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 16 p.

Dawson, J. O.; Countryman, D. W.; Fittlin, R. R. Soil and vegetation patterns in northeastern Iowa campgrounds. J. Soil and Water Conserv. 33:39-41; 1978.

Dotzenko, A. D.; Papamichoa, N. T.; Ramine, D. S. Effect of recreational use on soil and moisture conditions in Rocky Mountain National Park. J. Soil and Water Conserv. 22:196-197; 1967.

Dykema, Jean Anne. Ecological impact of camping upon the southern Sierra Nevada. Los Angeles, CA: Univ. of California. 1971. 156 p. Ph.D. dissertation.

Easterbrook, A. L. The effects of soil compaction on the occurrence of vegetatively reproducing plants in campsites. Ann Arbor, MI: Univ. of Michigan; 1968. 8-978 p. M.S. thesis.

Fichtler, Richard K. The relationship of recreational impacts on backcountry campsites to selected Montana habitat types. Missoula, MT: Univ. of Montana; 1980. 109 p. M.S. thesis.

Frissell, Sidney S. The impact of wilderness visitors on natural ecosystems. 1973. Unpublished report on file at USDA For. Ser., For. Sci. Lab. Missoula, Montana. 60 p.

Frissell, Sidney S.; Stankey, George H. Wilderness environmental quality: search for social and ecological harmony. Proc. Soc. Am. For.; 1972:170-183.

Hendee, John C.; Clark, Roger N.; Hogans, Mack L; Wood, Dan; Koch, Russell W. Code-A-Site: a system for inventory of dispersed recreational sites in roaded areas, backcountry, and wilderness. Res. Pap. PNW-209. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1976. 33 p.

Hingston, S. G. Revegetation of subalpine backcountry campgrounds: principles and guidelines. Res. Manage. Rep. Ser. KR-3. Recreation and Parks Division, Alberta, Canada; 1982.

Holmes, D. O.; Dobson. Ecological carrying capacity research: Yosemite National Park: Part I. Available U.S. Department of Commerce, Nat. Tech. Inf. Serv., NP. PB270-955. 1976. 247 p.

Isaac, R. A.; Johnson, W.C. Determination of total nitrogen in plant tissue, using block digestor. Journal of the AOAC. 59(1):98-100; 1976.

LaPage, Wilber F. Some observations on campground trampling and ground cover response. Res. Pap. NE-68. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1967. 11 p.

Mackintosh, E. E. Impact of recreation on vegetation an soils in Rushing River Provincial Park, Ontario. Report 0-X-290, Canadian Forest Service, Sault Ste. Marie, Ontario, Canada. 1979.

Minore, Don C.; Smith, Clark E.; Woodland, Robert F. Effects of high soil density on seedling root growth of seven northwestern tree species. Res. Note PNW-112. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1969.

Monti, P.; Mackintosh, E. E. Effect of camping on surface sod properties in the boreal forest region of northwestern Ontario. Soil Sci. Soc. of Amer. Journal. 43:1024-1029; 1979.

Parsons, David J.; DeBenedetti, Steven H. Wilderness protection in the high Sierra: effect of a 15-year closure. In: Linn, R. ed. Proceeding First Conference on Scientific Research in National Parks. U.S. Department of Interior, National Park Service Trans. and Proc. Series No. 5. 1979. 1313-1317.

Parsons, David J.; MacLeod, Susan A. Measuring impacts of wilderness use. Parks 5(3):8-12; 1980.

Perkin-Elmer Company. Analytical methods for atomic absorption spectrophotometry. Norwalk, Connecticut. 1976.

Peters, D. B. Water availability. In: Black, C. A. ed. Methods of soil analysis, Part I. Amer. Soc. Agron. Inc. 1965. 279-285.

Ranz, Beth. Closing wilderness campsites: visitor use problems and ecological recovery in the Selway-Bitterroot Wilderness, Montana. Missoula, MT: Univ. Montana; 1979, 125 p. M.S. thesis.

Rutherford, G. K.; Scott, D. C. The impact of recreational use on soil chemistry in a provincial park. Park News 15:22-25; 1979.

Schreiner, Edward S.; Moorhead, Bruce B. Human impact inventory and management in the Olympic National Park backcountry. In: Ittner, R.; Potter, D. R.; Agee, J. K.; Anschell, S., eds. Recreational impact on wildlands. R-6-001-1979. U.S. Department of Agriculture, Forest Service, Portland, OR: Pacific Northwest Region; 1979:203-212.

Settergren, C. D.; Cole, D. M. Recreation effects on soil and vegetation in the Missouri Ozarks. J. For. 68:231-233; 1970.

Stohlgren, Thomas J. Vegetation and soil recovery of subalpine campsites in Sequoia National Park, California. Fresno, CA: Calif. State University; 1982. 49 p. M.A. thesis.

Young, R. A.; Gilmore, A. R. Effects of various camping intensities on soil properties in Illinois campgrounds. Soil Sci. Soc. Amer. Journal 40:908-911; 1976.

THE EFFECT OF TWO HIKING INTENSITIES ON WILDLAND TRAIL WEAR

Fred R. Kuss

ABSTRACT: The effects of hiking experimental trails composed of fine sandy loam soils at two intensity levels equal to 600 and 2400 passes delivered over a six week period were compared in 1978, 1979, 1980 and 1982. Results of six separate experiments indicated erosion of low-intensity hiked plots was linearly related to the number of impacts. Conversely, high-intensity hiked plots showed a curvilinear relationship to impacts in the early stages of these experiments. The degree of change in trail depth, cross-sectional area, and soil penetration resistance was found to be use-level independent with greatest change occurring under low use. Extent of trail wear as evidenced by the total amount of material eroded from the trails was clearly a function of the total number of impacts. However, this distinction was not expressed until after 800 to 1200 hiking passes had been imposed on fine sandy loam soils. These results were attributed to an initial stabilization of the treadways by the combined effects of compaction and the incorporation of more surface organic matter into these surfaces as a result of the high level of use.

INTRODUCTION

Trail management planning has a number of implications to recreational use of wildlands including ecological, aesthetic, and experiential considerations. Problems related to erosion and degradation of hiking trails cut across all of these concerns as well as the matter of increased maintenance and relocation costs. With increasing frequency, concerns about the physical deterioration of trail systems are mentioned in the literature (Bryan 1977; Cole 1983; Goetz 1975). Stabilization of trail systems requires continuous assessment of site variables that may contribute to the instability of seriously impaired trail segments as well as periodic monitoring of trails for indications of serious change (Cole 1983).

Two important factors which affect the rate and magnitude by which trails degrade are the intensity and extent of use. Much of the present information dealing with the quantitative and qualitative effects of use levels on trail wear is derived from ex post facto studies of existing systems which offer little in the way of defining relationships associated with early stages of degradation. This paper summarizes five years of study designed to quantify the effects of hiking on wildland trails and describes the physical effects of two hiking intensities on experimental trails located in the Hubbard Brook Experimental Forest, Thornton, New Hampshire, and in southwestern Virginia. Where appropriate, discussion will also include results of experiments where only a single hiking intensity was evaluated.

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REVIEW OF LITERATURE

Few studies have dealt with the quantitative effects of different hiking intensities on trail wear. Notable contributions have been made by Dale (1973); Dale and Weaver (1974); and Weaver and others 1979). These studies have demonstrated a linear relationship between increases in trail width and the number of users. However, the greatest amount of change in trail depth occurred under small amounts of use. Similar findings have been reported for Wilderness trail conditions by Cole (1983) and Helgath (1975). In a comparative study of lightly and heavily used trails in the Selway-Bitterroot Wilderness, Cole (1983) found the heavily used trail to be significantly greater in width and in the amount of surface barren of vegetative cover than the lightly used trail. However, maximum depths of the two systems were not statistically different, indicating that the erosional effects of the use intensity variable were not reflected in change in the depth of these trails.

Degree of trail damage is reported to be more a function of trail slope, orientation, soil type, and ground water conditions than use (Root and Knapik 1972). The extent of damage is thought to be dependent on forest or vegetation type, geology, elevation, and slope as well as the amount of use. Even on lightly used trails there may be extensive erosional damage when the influence of variables other than use are expressed (Bratton and others 1979).

As a result of limited studies, trail wear has been assumed to be a direct corollary of use (Bryan 1977). However, the question of whether soils and vegetation respond differently when trampling impacts are concentrated in time of delivery or delivered in intervals over time has been raised in recent studies. Results have been variable. Some investigators have reported no difference in the rate or degree of impact change (Rogova 1976; Singer 1971). Others suggest that less damage occurs under low

intensities of use when the total number of impacts are delivered over time while at high use levels, concentrating the impact loads produces less damage than when the same number of impacts are delivered over time (Landals and Scotter 1973). Generally, the degree of change in the physical properties of coarse soils brought about by hiking pressures has been found to be curvilinear with the greatest change occurring at low-use intensities (Jones 1978).

DESCRIPTION OF AREAS

The study was conducted on two experimental trail systems located in the Hubbard Brook Experimental Forest, West Thornton, New Hampshire, during the summers of 1978 to 1982 and on private lands in southwestern Virginia in 1980. The forest is characterized by an unbroken canopy of second growth northern hardwoods with patches of spruce and fir at the higher elevations of the system. The experimental area was logged between 1909 and 1917 resulting in a present uneven-aged northern hardwood stand 60-70 years old. Principal tree species in this section are *Acer saccharum*, *Fagus grandifolia*, and *Betula lutea*. Dominant species of the understory are *Viburnum alnifolium*, *Acer saccharum*, and *Fagus grandifolia*, and important herbaceous species of the forb layer are *Dryopteris spinulosa*, *Maianthemum canadense*, and *Oxalis montana*.

Slope of the experimental trail systems averaged 9 percent in the 1978-79-80 studies. A new location was used in the 1981-82 studies where slope of the plots ranged from 20 to 25 percent. Both trail systems were oriented to the north and tree canopy densities were estimated to be 70 to 90 percent. Soils were a Madawaska fine sandy loam covered with a mor humus layer (1978-79-80) and a Berkshire stony fine sandy loam (1981-82). The Virginia study was located on private lands in the southwestern section of the state. Experimental plots were located in an open field system that had lain fallow for ten years. The soil was classed as a fine loamy mixed mesic having less than 35 percent fines. Vegetative cover was dominated by a thick tussocky growth of *Dactylis glomerata* growing on slopes of 20-25 percent. Aspect was westerly.

MATERIALS AND METHODS

A series of plots measuring 10 x 2 feet (3.048 x 0.609 m) were prepared along each experimental trail corridor and separated by buffer strips of undisturbed surfaces. In the forested areas the O_1 material was removed from each plot with leaf rakes and all vascular plants and surface roots traversing the plot were removed. At the open field location, two treadway surfaces were prepared to include those covered with a thick thatch of turf and those stripped of turf to expose the mineral soil. Water bars were placed at the head of each plot and collector units installed at the lower end of each plot. Collector units used in these studies are described in previous papers (Kuss 1983; Kuss and Jenkins 1985).

Treatments

Hiking impacts were delivered by hikers weighing 110 to 190 pounds (41.05-70.91 Kg). Two hiking intensities were followed: low-use intensity representing a total of 600 trampling passes per plot and high-use intensity equal to 2400 passes per plot. The hiking schedule was followed at approximately seven-day intervals for a period of six weeks, representing 100 and 400 trampling impacts per week for the low and high intensity plots respectively. Hikers wore conventional hiking boots during the impact schedule. Experiments in both 1978 and 1982 were duplicated. Plot treatments were randomized as were the delivery of hiker impacts. Collections were made by rain-event and in all experiments, each treatment was replicated three times.

Materials washed from the plots were processed and stored for dry weight and organic matter determinations. For moisture content determinations, replicate soil cores were taken prior to each impact schedule. Soil penetration resistance was measured by a Soil Test Pocket Penetrometer.

Cross-Sectional Profiles

Prior to and after hiking impacts were completed, cross-sectional measurements were taken from three transects established at 1, 5, and 9 feet (0.3, 1.52, 2.74 m) from the upper boundary of each plot. Five measurements spaced at 6 inch (15.24 cm) intervals were made from a 3 feet x 5/8 inch (91.4 x 1.59 cm) metal rod held in place at each transect by two survey stakes having predrilled 3/4 inch (1.9 cm) holes through which the rod was suspended. Stakes were matched to level by use of a hand level taped to the rod center. Measurements from the rod to plot surface were made with a metal carpenter's combination square consisting of a metal rule and an attached metal square mounted at right angles to the rule. The square contained a built-in level which allowed for verifying the vertical perpendicular from the rod. After orienting to the perpendicular as indicated by the level, the rule was lowered until contact with the ground was made. Distances recorded to the nearest 0.1 centimeter were read directly from the rule. Stakes were reset each year of study.

RESULTS

Erosion Yields

For purposes of comparison, erosion yields measured in grams dry weight were projected to pounds per mile and kg per km of trail surface

based upon a 100-day use season. These weights include both sediment and organic matter washed into the collectors during periodic rain events. Low-use hiking was equal to the two-way travel of 9 to 13 hikers per week while high use corresponded to 34 to 52 hikers per week. Natural background yields from the various surfaces tested ranged from 34 to 612 pounds per mile (10 to 172 kg/km); low use from 63 to 1503 pounds (18 to 423 kg); and high-use yields projected to 116 to 2907 pounds per linear mile (33 to 819 kg/km) of trail surface.

In all, seven experiments were conducted dealing with differences between low and high use impacts on trail wear. Differences in yields between untreated and low-use plots shown in table 1 were significant at the P = .05-.001 level of confidence. All comparisons between low use and high use yields were also significant (P = .05-.001) except in one case. Analysis of these data indicated P values of 0.10-0.15. This was considered of practical significance since the system was responding in the direction of the six other experiments and the surfaces were comparatively dry. Analysis was by ANOVA and Mann Whitney U Tests.

When the ratios of differences between yields were calculated, the data show close agreement between and within years of study (table 1). Differences in yields between low-use plots and untreated plots averaged 2.2 fold; between high-use and untreated plots a 3.3 fold difference: and between high- and low-use plots a 1.8 fold increase in yields. These figures were derived from different experiments where the hiked surfaces were mor humus, turf, or exposed mineral soil.

Comparisons Between and Within Treadway Types

Between-year comparisons of yields from different treatments appear quite consistent when the same surfaces are compared (table 1). For example, the ratios of differences between treatments on mor surfaces between 1978 (dry) and 1979 (moist) show close agreement (i.e., untreated 4.2, low use 3.6, and high use 4.0). Since the slope, treadway surface, canopy density, soil, elevation, and aspect were similar between years of testing, the moisture variable is thought to account for much of these differences. Consequently, it appears that a 1.6 fold increase in the moisture content of these surfaces (21 vs. 33 percent)

Table 1.--Comparative erosion yields of different treatments

Year	Environment	Treatment	Erosion Yields[1] Pounds/ Mile	Erosion Yields[1] Kg/Km	Ratio of Differences Untreated vs. Treatment	Ratio of Differences Low vs. High Use
[2]1978	Forest	Untreated	34	10	-	-
[3](Mor)		Low Use	63	18	1.8	-
		High Use	116	33	3.4	1.8
1979	Forest	Untreated	143	40	-	-
(Mor)		Low Use	223	63	1.6	-
		High Use	458	129	3.2	2.0
1980	Forest	Untreated	121	34	-	-
(Mor)		Low Use	-	-	-	-
		High Use	216	61	1.8	-
1980	Forest	Untreated	483	136	-	-
(Mineral)		Low Use	-	-	-	-
		High Use	923	260	1.9	-
1980	Field	Untreated	92	26	-	-
(Turf)		Low Use	333	94	3.6	-
		High Use	497	140	5.4	1.5
1980	Field	Untreated	612	172	-	-
(Mineral)		Low Use	1503	423	2.4	-
		High Use	2907	819	4.8	1.9
1981	Forest	Untreated	430	121	-	-
(Mineral)		Low Use	-	-	-	-
		High Use	1392	392	3.2	-
[2]1982	Forest	Untreated	192	54	-	-
(Mineral)		Low Use	348	98	1.8	-
		High Use	556	157	2.9	1.6

[1]Yields rounded off to nearest whole number.
[2]Average of two experiments.
[3]Type of treadway surface.

accounted for a composite four-fold difference in yields. While the magnitude of differences was not as great, comparisons of erosion yields from mineral surfaces at the same location indicate close agreement (untreated 2.2 and high use 2.5) between the results of the 1981 (moist) and 1982 (dry) studies. Here again, the moisture variable appears to be the major factor influencing these differences.

Comparisons between two different surfaces treated the same year (mor vs. mineral [1980] and turf vs. mineral [1980]) show similar consistencies. Exposed mineral soil surfaces were shown to erode 4.2 times greater under a forest canopy when compared to mor surfaces and 4.6 times greater when compared to turf covered treadways under no overstory canopy.

Relationships of Yields to Number of Impacts

Data which consolidate the means of five experiments conducted in the forested systems were plotted on a Logarithmic Scale to show impact-response relationships between cumulative erosion yields and the total number of impacts conferred on the system at time of collection. Yields from the low-use plots showed a linear relationship to number of impacts. Conversely, a curvilinear relationship was revealed when high-use levels were considered indicating a decided lag in erosion yields occurred in the high-use plots during the early stages of the experiments (fig. 1). A similar curve was shown with the exposed mineral soil in an open field setting. Turf covered treadways did not show this pattern. Responses to both high- and low-use impacts were linear.

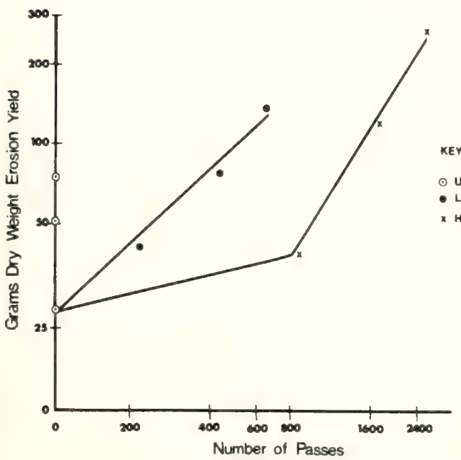

Figure 1. Impact-responses graph showing cumulative erosion yields from untreated trail segments and those hiked at two levels of intensity.

Analysis of the yield data by collection date revealed that major differences in the rate of erosion between low- and high-use plots were not expressed until the second or third collections and peaked during the final collections. It should be noted that it was not until after 800 to 1200 impacts were imposed on the system that significantly greater yields were expressed by the high-use plots when compared to plots receiving low use.

The effect of two hiking intensities on trail profile changes is shown in figure 2. Data from the 1982 studies were used to demonstrate these effects which are similar but different in magnitude to changes recorded during previous years. Using the method for calculating cross-section area change suggested by Cole (1983), changes in the low-use plots averaged 18 percent less than the high-use plots. When compared to the untreated plots, high-use levels resulted in a 2.4 fold increase in cross-sectional area change, while on low-use plots a 2.0 fold increase occurred. These changes represent the combined effects of soil and organic matter loss, soil deformation by compaction, and soil redeposition. By way of comparison, yields from these plots were 2.9 and 1.8 times those of the untreated plots.

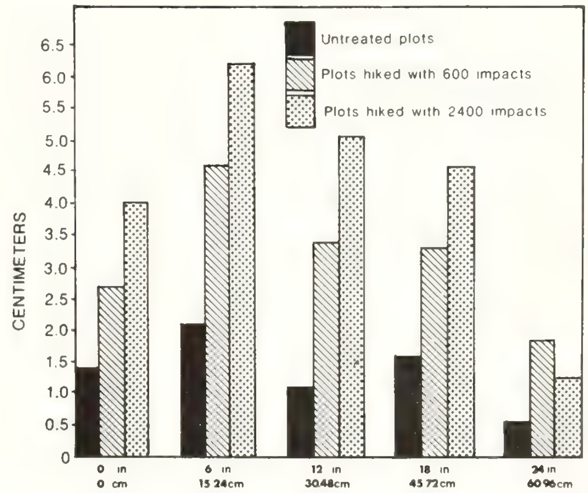

Figure 2.--Changes in cross-sectional profiles of trail segments in response to three different treatments (average of six replicate measurements each).

In comparing the 1980 data from the forested area when both mor and mineral surfaces were profiled, similar cross-sectional changes were found, yet erosion yields from the mineral surfaces were 4.6 times that from the mor surfaces. Cubic volume conversions of the erosion yields from the mineral surfaces accounted for only 5.1 percent of the calculated volume changes in the plots. These findings are both consistent with the predicted degree of deformation caused by compaction of these soils

and with surface sheet erosion of mineral surfaces bared of vegetation or litter (Kuss and others 1984). Consequently, profile changes were due primarily to the weights of the hikers rather than to soil loss.

Soil displacement and reduced infiltration rates combine to increase both the volume of run-off and entrained soil and organic matter particles. An example of this effect was the volume of run-off and erosion yields collected from untreated plots during the 1981 and 1982 studies. Average total volume of run-off collected from untreated plots amounted to 17 liters, while the average volume collected from treated plots equaled 29 liters. Over time these surfaces became more compacted resulting in a decline in infiltration rates. As a result of these effects, surfaces of the trails became more vulnerable to erosion. Hiked plots showed a 1.7 fold increase in run-off as measured in liters when compared to the untreated surfaces. Volumes of run-off collected from low- and high-use plots were not significantly different.

Changes in Soil Penetration Resistance (SPR)

Variations in erosion yields obtained from these experiments reflect the influence of a number of variables such as rainfall patterns, soils and soil moisture content, groundwater levels, bulk densities, pre-experiment precipitation, and slope variations. Soil moisture content varied considerably ranging from a low of 8 percent to a high of 45 percent. Average soil moisture content for the years of study are shown in parenthesis: 1978 (21 percent), 1979 (33 percent), 1980 (16 percent), 1981 (23 percent), and 1982 (12 percent). These variations did not influence the pattern in trail erosion responses to the two different use intensities in terms of impact-erosion curves. Soil penetration resistance varied from 1.15 to 4.45 kg per cm^2.

The effects of hiking and natural change were reflected in variable changes in SPR which showed a progressive increase over time under hiking pressures. Mean change for the control plots equaled minus 10 percent, low-use plots showed a net increase of 20 percent while high-use plots showed a net 32 percent increase over pre-treatment measurements.

Physical Changes in the Treadway

Deformation of the treadways caused by two levels of use was expressed by changes in depth of the central core of the treadway (12 inches; 0.03 m), by cross-sectional area changes, by erosion yields, and by changes in soil penetration resistance (SPR). These data are shown in table 2. Comparisons between differences in measurements of these four parameters for the high- and low-use plots and the untreated plots indicate that the greatest change occurred between low-use and the control plots. Overall, when these data are pooled, a 77 percent increase in these four parameters occurred between changes in the untreated and low-use plots (600 passes). High use (2400 passes) accounted for an additional 36 percent increase above the low-use levels of change. When differences in SPR are omitted from these calculations, a 96 percent difference between low use and the controls occurred, while high use increased differences between low use by 44 percent. Highest increases in change were due to materials eroded from the plots.

DISCUSSION

Relationships described in the preceding section indicate that the rates of erosion of trails hiked at low- and high-use intensities were similar up to the point where approximately one-third to half of the high-use impacts had been delivered. Damage accruing from dispersing low use over a six-week period was approximately equal to concentrating high use over a three week period under forested conditions. In an open field system this relationship was condensed to the first two weeks of trampling (200 impacts = to 800). Consequently concentrating use or large group use of trails may have less impact than previously thought at least by the standards and conditions of this study.

There are perhaps two explanations for these consistencies. According to Bryan (1977) and Arndt (1966), compaction such as caused by hiking may function to increase soil aggregation and act to stabilize exposed soil surfaces. As Bryan states, "When pressure is exerted on soil, aggregation initially increases up to a threshhold determined by the soil shearing strength. Thereafter it declines, eventually dropping to

Table 2.--Physical changes in soil parameters impacted by two levels of use

Treatments	Percent Increase: Depth of Central Core	Cross-Sectional Volume	Erosion Yields	SPR
Control vs. low use	94	68	127	20
Low use vs. high use	35	23	73	12
Control vs. high use	180	113	284	32

zero. The threshold is very variable depending on grain size and shape and on colloidal content . . ."

Fine sandy loams such as found in the study areas are subject to deformation by compacting forces, the degree of deformation related to moisture content. Moreover K factors for these soils ranged from .24 to .28 indicating comparatively modest erodibility. According to engineering data, these soils have good shearing strength under compaction loads. It would appear that as more impacts were imposed on the high-use hiked plots, a critical threshold was reached where the combined effects of increased compaction as evidenced by SPR and loss of shear strength resulted in highly erodible surfaces in the high-use plots as reflected by the surge in yields in the latter part of the experiments.

The degree to which soils are compacted is dependent upon texture, porosity, moisture content, and the duration and intensity of use. Consequently, a wide range of responses to the effects of trampling may be expected. Moreover, these effects will vary greatly according to the original density and consistency of finer grained soils. Variations in soil consistency are commonly referred to as hard, friable, plastic, and liquid which correspond to firm, medium soft, soft, and very loose consistencies. Information contained in table 3 illustrates the effect of water content on the behavior of cohesive soils. As moisture content increases, soil consistency changes from firm to plastic and resistance to compaction declines as does the ability of soil to carry traffic. Soil adhesion to boots also increases with moisture content until very wet conditions prevail.

It is important to consider the consistency variable in trail assessments which is related to soil texture and moisture conditions prevailing during the primary use season. Soils involved in this study are subject to consistency change, deformation by weight loads as evidenced by the data, have low plastic properties but are susceptible to frost action. This together with ground water variations may explain the change in the cross-sectional area of the control plots and the negative change in SPR.

A second influence that might have contributed to the temporary stabilization of the high-use plots is hypothesized to have occurred as a result of greater amounts of organic matter being incorporated into those surfaces. More pulverization of organic litter and debris occurred under increased use of the central core of the treadways. The finer particles of the organic debris are thought to have been incorporated into the soil by the repeated pressures of hiking. This hypothesis is in accord with observations made by Monti and MacKintosh (1979) and Legg (1973) that leaf and needle litter may be incorporated into the A horizon by limited use, thus conferring greater stability to the impacted surfaces. Unfortunately, loss on ignition analyses were not conducted in all years of the study.

Changes in physical features of the treadways are similar to those reported by other investigators. Curvilinear relationships between amount of use and trail depth and bulk density increases were reported by Weaver and Dale (1978). Greatest change occurred under low use. Under a mixed northern hardwood, a spruce-fir canopy, on sandy loam soils, Leonard and others (1985) reported that the greatest degree of soil compaction occurred under low-use hiking levels (<250 tramples). Jones (1978) found that the greatest change in depth and SPR of coarse soils occurred under low trampling intensities (64 to 128 passes). These results suggest that fine sandy loam soils behave similarly to coarser soils in terms of physical parameters dealing with density-compaction-pore space interactions. Moreover, Whitaker (1978) reported that while hiking caused slight increases in compaction, a highly significant decrease in depth of leaf litter occurred under low use on trails having an overstory canopy of southern hardwoods.

In a study of the Appalachian Trail in Great Smoky Mountains National Park, Burde and Renfro (1985) report that cross-sectional change was related to soil type, vegetation type, precipitation, and trail slope. Sandy loam and loam soils were most sensitive to hiking impacts in terms of cross-sectional changes, depth, width, and amount of surface barren of vegetative cover. Their findings also indicate that trail depth was influenced by use levels.

Should these findings hold up under studies of other ecosystems, these changes may partially explain the curvilinear relationship of plant decline to use. Changes in pore space which influence aeration, moisture content, and water transmission properties apparently occur rapidly under low-use levels as the soil becomes

Table 3.--Effect of water content on the behavior of a cohesive soil (Marshall and Holmes 1979)

	Water Content			
	Dry	Moist	Wet	Very Wet
Consistency	Hard	Friable	Plastic	Liquid
Ability to carry traffic	High	High	Low	Very low
Adhesion	Very low	Low	High	Low
Resistance to compaction	High	Moderate	Low	High

more dense. These changes may dispose the plant cover to sufficient stress to cause the declines reported by a number of studies that have focused only on plant responses to impact.

MANAGEMENT IMPLICATIONS

Results of this study may explain in part why trails receiving low use show greater wear than comparable highly used trails. It also cautions against drawing inferences that cross-sectional area changes are due primarily to erosion rather than weight loads and deformation. In terms of newly constructed trails it is quite possible that moderate use may in fact stabilize the system through the compaction process and that group hiking may be more beneficial than damaging in this respect.

This study also suggests that trail degradation may be more a result of site location than use intensity. Strong association of physical and vegetative variables with trail wear, when compared to use intensities, has been reported by other investigators (Bratton and others 1979; Cole 1983; Helgath 1975).

Some of the more important location variables found to influence trail wear and maintenance were: canopy density, soil type and depth and kinds of organic matter covering the soil surface, soil moisture content, responses of soils to weight loads, and surface soil density. Slope did not appear to be as important as soil consistency, soil moisture content, or soil density in mediating trail erosion.

Surveys to locate unstable or potentially unstable trail conditions are recommended. More intensive maintenance of such areas is indicated. Trail problems can be reduced by steps taken to keep the treadway dry to firm and to encourage single-file hiking. Locating trails on surfaces that are subject to annual replacement of leaf litter can reduce problems of erosion. Clearly, the effect of humus layers is to stabilize trail surfaces.

Since moisture greatly affects soil consistency and susceptibility to compaction, trail planning and location designs should avoid low areas, surface and sub-surface seeps and bogs. New trail construction should follow the contours of the land form wherever possible rather than routing the trail directly up the fall line. The need for thorough pre-planning and site-specific surveys before site commitment should be emphasized. Thus, before decisions are made that will commit management to maintaining poorly designed systems, extensive field investigations should be undertaken to find the best possible trail routes.

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REFERENCES

Arndt, W. The effect of traffic compaction on a number of soil properties. Journal of Agricultural Engineering Research. 11: 182-187; 1966.

Bratton, S. P.; Hickley, M. G.; Graves, J. H. Trail erosion patterns in Great Smoky Mountains National Park. Environmental Management, 3: 431-445; 1979.

Bryan, Rorke B. The influence of soil properties on degradation of mountain hiking trails at Grovelsjon. Geografiska Annaler. 59A: 49-65; 1977.

Burde, John H. Renfro, James R. Use impacts on Appalachian Trail. [In press].

Cole, David N. Assessing and monitoring backcountry trail conditions. Research Paper INT-303, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 10 p.

Dale, D. R. Effects of trail use under forests in the Madison Range, Montana. Bozeman, MT: Montana State University; 1973. 96 p. M.S. thesis.

Dale, T.; Weaver, T. Trampling effects on vegetation of the trail corridors of North Rocky Mountain forest. Journal of Applied Ecology. 11: 767-772; 1974.

Goetze, C. Will we all participate in backcountry decisions? Appalachia. 160: 7-20; 1975.

Helgath, S. F. Trail deterioration in the Selway-Bitteroot Wilderness. Research Note INT-193.. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1975. 15 p.

Jones, D. H. The effect of pedestrian impact on selected soils. Glasgow, Scotland: University of Glasgow; 1978. 154 p. M.S. thesis.

Kuss, F. R. Hiking boot impacts on woodland trails. Journal of Soil and Water Conservation. 38(2): 119-121; 1983.

Kuss, Fred R.; Jenkins, William A. Effects of footgear design on trail wear: A summary of five years. In: Fedler, Anthony J.; Anderson, L. M., Editors. Proceedings -- Southeastern Recreation Research Conference; 1984 February 16-17; Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.

Kuss, F. R.; Vaske, J. J.; Graefe, A. R. Review and synthesis of recreational carrying capacity literature. Department of Recreation, University of Maryland. Report to National Parks and Conservation Association, Washington, D.C.; 1984. 181 p.

Landals. M.; Scotter, G. W. Visitor impact on meadows near Lake O'Hara, Yoho National Park; 1973. Unpublished report on file at: Canadian Wildlife Services, Edmonton, Alberta.

Legg, M. Site factors useful in predicting deterioration of forest campsites in northern Michigan. East Lansing, MI: Michigan State University; 1973. 99 p. Ph.D. dissertation.

Leonard, R. E.; McMahon, J. L.; Kehoe, K. M. Hiker trampling impacts on eastern forests. Research paper NE-555, Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1985. 5 p.

Monti, P.; Mackintosh, E. E. Effect of camping on soil properties in the boreal region of northwestern Ontario, Canada. Soil Sciences and Sociology American Journal. 43: 1024-1029; 1979.

Rogova, V. Influence of trampling on vegetation of forest meadow and whortle berry-moss-pine forest cenoses. Soviet Journal of Ecology. 7: 356-359; 1976.

Root, J. D.; and Knapik, L. J. Trail conditions along a portion of the Great Divide trail route, Alberta and British Columbia Rocky Mountains. Edmonton, Alberta: Research Council, Alberta; 1972. Report 72-5, 24 p.

Singer, S. W. Vegetation response to single and repeated walking stresses in an alpine ecosystem. New Brunswick, NJ: Rutgers University; 1971. 69 p. M.S. thesis.

Weaver, T.; Dale, Donn; Hartley, E. The relationship of trail condition to use, vegetation, user, slope season and time. In: Ittner, Ruth; Potter, Dale R.; Agee, James, K.; Anschell, Susan, Editors. Proceedings -- Recreation impact on wildland conference; 1978 October 27-29; Seattle, WA. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, U.S. Department of Interior, National Park Service. R-6-001-1979. 94-100.

Whittaker, P. L. Comparison of surface impact by hiking and horseback riding in the Great Smoky Mountains National Park, Gatlinburg, TN. U.S. Department of Interior, National Park Service, Southeast Region; 1978; Management Report No. 24. 32 p.

USER STANDARDS FOR ECOLOGICAL IMPACTS AT WILDERNESS CAMPSITES

Bo Shelby and Rick Harris

ABSTRACT: Traditionally, evaluative standards for campsites have been based on expert judgments, although several studies show that judgments of managers often differ from those of users. Other studies have focused on user evaluations of campsite impacts, but have not identified the point at which impacts become unacceptable. Although conclusions are speculative, data from the present study suggest that wilderness users have opinions about impacts and are willing to express them, norms or standards vary for different experiences offered by different locations, low to moderate impact may be more acceptable to users than no impact at all, and there is considerable agreement about impact standards.

INTRODUCTION

According to the Wilderness Act, wilderness is meant to be used and enjoyed. Yet it is defined as "affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable" (Public Law 88-577). Managers of wilderness areas would probably agree that wilderness should be managed on a non-degradation concept, but it is obvious that use and enjoyment of an area cannot occur without some form of measurable impact.

Over the past 20 years recreational use of wildlands has increased dramatically. At least 20 times as many people visit wilderness now as compared to the 1930's (Hendee and others 1978). This increase in use has caused managers and visitors alike to worry that many wildland recreation areas are being overused.

Overuse issues can be conceptualized in terms of descriptive and evaluative components (Shelby and Heberlein 1984). In terms of the descriptive component, impacts are the specific problem conditions which result from overuse. Impacts can be biological (soil compaction or ground cover losses), social (encounters at camps or on trails), or associated with facilities (space available in parking areas). A first step in working with overuse problems is to identify and describe the specific impacts of greatest concern (Stankey and McCool 1984).

The evaluative component of overuse problems usually proves more difficult. The evaluative component involves value judgments about specific levels of impact which can be used to develop evaluative standards. Evaluative standards specify which level of impact is tolerable (the maximum) or most desirable (the optimum).

Problems sometimes arise in deciding whose value judgments will be used in establishing these standards. Ultimately managers will specify standards which are based on sound management objectives and other factors, but should these decisions be based on managers' viewpoints alone? For the most part, evaluative standards which define acceptable limits of change (especially ecological change) for wilderness areas have been based on the value judgments of managers. These judgments often lack information about how visitors to these areas perceive impacts.

Managers are usually concerned about site degradation, but it does not follow that the public will perceive such degradation as unacceptable or undesirable (Hendee and Harris 1970). In a study by Lucas (1970), Forest Service administrators ranked the quality of recreational sites much differently than users. Peterson (1974) also found that managers were more aware of "the depreciatory consequences of recreation use" than visitors. Brown and Shoemaker (1974), in a study which looked at functional and desirable characteristics of existing sites in the Spanish Peaks Primitive Area, concluded that from the visitor's perspective the "best" sites were the ones with the heaviest impact.

Most managers are trained in the biological sciences and are familiar with ecological processes, and working in the same environment over a period of time gives them the opportunity to observe trends. In contrast, visitors generally deal with impacts which are confined to individual sites, and are not aware of change which takes place over time or throughout management units (Hendee and Pyle 1971). Managers may also be directed by regional guidelines or forest policy to take action in some instances.

So although impacts beyond a certain point are perceived by managers as unacceptable, the

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question remains: Does the visitor perceive the same degree of impact as unacceptable? The available literature which focuses on campsite impacts suggests that campsite degradation resulting from visitor impact does not significantly influence visitors' choices of campsites or their overall satisfaction with a particular site (Lucas 1979). A study by Dunwiddie and Heberlein (1975) observing visitors in the Wind River Mountains of Wyoming showed that the most important factor in campsite selection was that the site characteristics meet the structural needs of the group (such as size, principal activity, and method of cooking). The authors also observed that "worn and littered" sites were more frequently selected by visitors.

How visitors perceive campsite impacts is not well documented. Studies which do look at visitor evaluations of campsite impacts (Frissell and Duncan 1965; Stankey 1973; Lee 1975; Merriam and Smith 1978; Harris 1978) generally focus on how the impacts relate to levels of satisfaction and nót whether the impacts are perceived as acceptable or unacceptable. According to Lucas (1980), knowledge about impacts lacks clear goals and a definition of acceptable conditions. The goals of this paper are to (1) develop a method for collecting and organizing information about user standards for ecological impacts at campsites, and (2) present data showing user standards for bare ground and fire rings for the Mt. Jefferson Wilderness.

The measurement of visitor standards has been developed by Vaske (1978), Shelby (1981), and Shelby and Heberlein (in press). These approaches identify five important characteristics of standards or norms (Shelby 1981). Personal norms or preferences refer to individual standards, while social norms combine individual preferences to form group or collective standards. The range of tolerable conditions defines the scope of acceptable situations, intensity shows how strongly norms are held, and crystallization is a measure of group agreement. For example, evaluative standards for encounters in a wilderness setting might have a low range of tolerable contacts, high intensity, and high crystallization, while norms for a city sidewalk would show a greater tolerable range, lower intensity, and less group agreement (Heberlein 1977).

METHOD

Data for this study were collected in the Mt. Jefferson Wilderness, Oregon (see Shelby and Harris in press for complete details of study methodology). Situated along the crest of the Oregon Cascades 100 miles southeast of Portland, the area offers a variety of recreation opportunities including hiking, climbing, horse riding, fishing, and hunting.

Five study areas were selected, and within each study three presentation methods (on-site, photographic, and written description) were used. The Scout Lake bare ground study area contained four campsites, the Bays Lake bare ground study area contained three sites, and the Hunts Lake bare ground study area contained five sites. The Russell Lake and Hunts Lake fire ring study areas each contained four campsites. Individual respondents evaluated the campsites in only one study area.

Within each study area, campsite selection criteria were (a) close proximity to one another so that walking time for respondents evaluating a particular group of sites could be minimized, (b) obvious gradations of the impact (bare ground or fire rings) being evaluated, and (c) control (as best as possible) for such characteristics as view of scenic features, proximity to water, and suitability of tent spot. In some instances fire rings had to be constructed or modified. At campsites where bare ground was evaluated, fire rings were removed. Photographs and written descriptions were developed for all sites to allow comparison of presentation methods (see Shelby and Harris in press). Because results were generally comparable across methods, data were combined for the purposes of the present paper.

The study population included people 16 years or older who camped at least one night in one of the five study areas. At each study area 30 respondents were assigned to each measurement method, making a total of 90 persons at each of the five study areas. Of the 450 contacted, 427 agreed to participate, a 95 percent response rate.

The dependent variable was the acceptability of the impact in question. Each respondent evaluated only one kind of impact in one study area, using only one of the three presentation methods. In a structured interview, respondents were given a card with a five-point scale regarding the acceptability of the impact. The order for evaluating sites was randomized, and the time for each interview ranged from 15 to 25 minutes.

User standards were developed by combining individual acceptability ratings using techniques developed by Vaske (1978), Shelby (1981), and Shelby and Heberlein (in press). Approximately 90 subjects rated the acceptability of each particular fire ring or bare ground site, and a group mean was computed for each site. Mean acceptability ratings were then plotted for each site, producing "impact acceptability curves" for bare ground and fire rings.

RESULTS

Impact acceptability curves for fire rings at camps are shown in figure 1. The curve for fire rings at Hunts Lake shows that no fire ring and the 16-inch diameter fire ring were on average rated acceptable, while the 22-inch and 38-inch diameter fire rings were rated unacceptable. Interpolation suggests that the range of acceptable sizes for fire rings at Hunts Lake is from zero (no fire ring) to approximately 20 inches in diameter.

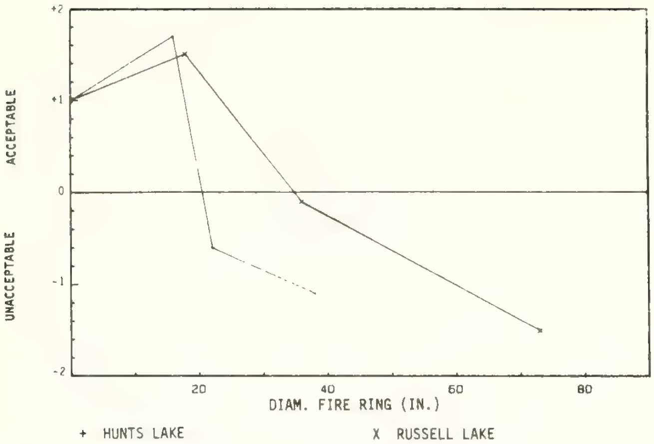

Figure 1.--Impact acceptability curves for fire rings.

For Russell Lake, no fire ring and the 18-inch diameter fire ring were rated acceptable. At this location, however, the average rating for the 36-inch fire ring was essentially neutral. The average rating for the 75-inch fire ring (which contained two connected barbeque areas) was unacceptable. For the Russell Lake location the range of acceptable sizes for fire rings appears to be from zero to approximately 34 inches in diameter.

Impact acceptability curves for bare ground are shown in figure 2. The curve for fire rings at Hunts Lake shows that the average rating for no bare ground was close to neutral. The 42 and 462 square foot bare ground areas were rated acceptable, while the 672 square foot area was close to neutral. The 1,404 square foot area was rated unacceptable.

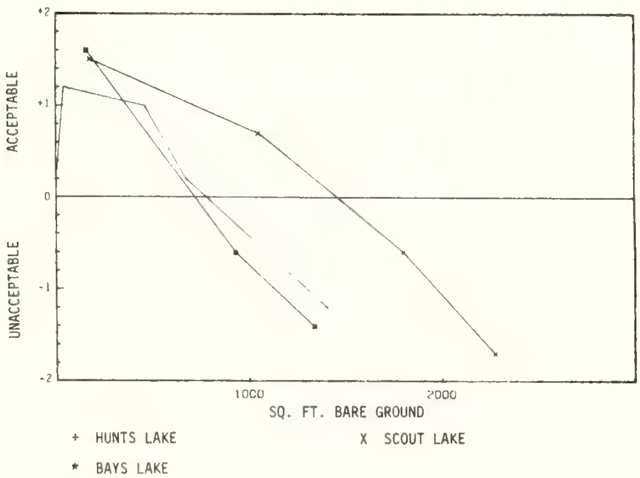

Figure 2.--Impact acceptability curves for bare ground.

The impact acceptability curve for Bays Lake closely approximates the findings from Hunts Lake. The 156 square foot area was rated acceptable, while the 928 and 1,332 square foot areas were rated unacceptable. Interpolation suggests that for the Hunts and Bays Lake areas the range of acceptable bare ground areas is from zero to approximately 750 square feet.

At Scout Lake, the 180 square foot area was, on average, rated acceptable. At this location, however, the 1,050 square foot area was considered acceptable (a contrast to the similar-sized area at Bays Lake). The 1,800 and 2,275 square foot areas were rated unacceptable. For the Scout Lake location the range of acceptable bare ground areas appears to be from zero to approximately 1,450 square feet.

There are two interesting findings common to the data on both fire rings and bare ground. First, small amounts of impact were rated more acceptable than no impact at all. Small fire rings were rated more acceptable than no fire ring, and small areas of bare ground were more acceptable than no bare ground. Second, acceptable impact levels appear to be different at different locations. Larger fire rings were acceptable at Russell Lake, and larger bare ground areas were acceptable at Scout Lake.

Crystallization of norms refers to the amount of agreement about standards. The amount of agreement about standards for fire rings is shown in figure 3. Agreement can be thought of as the percentage of respondents who rated a particular impact as either acceptable or unacceptable. At both Russell Lake and Hunts Lake, over 70 percent agreed that no fire ring was acceptable. Agreement increased to more than 90 percent for the 16-inch and 18-inch fire rings. At Hunts Lake, the 22-inch and 38-inch fire rings were unacceptable to 72 percent and 85 percent, respectively. The 36-inch fire ring at Russell Lake was the only one where there was no clear majority agreement; 49 percent found it acceptable, while 46 percent found it unacceptable. The 73-inch fire ring at Russell Lake was unacceptable to virtually everyone (99 percent).

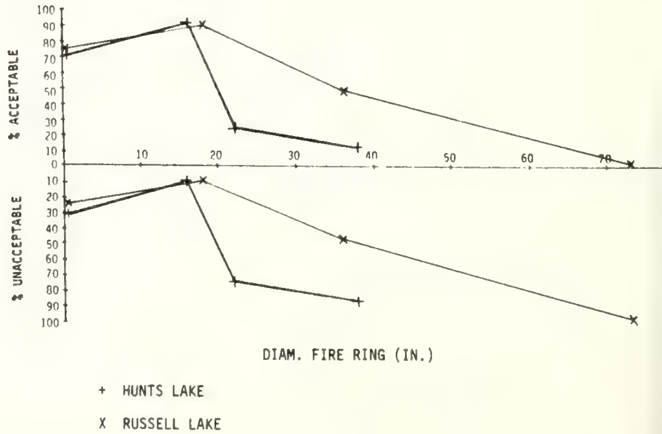

Figure 3.--Amount of agreement about standards for fire rings.

Crystallization of standards for bare ground is shown in figure 4. There is no clear majority agreement about the site at Hunts Lake with no bare ground. About 70 percent agree that 42 square feet of bare ground is acceptable, and for sites with 156 to 462 square feet, over 90 percent agree. Agreement drops to 58 percent for the 672 square foot site, and for the remaining sites at Bays and Hunts Lakes, 67 to 92 percent agree that the amount of bare ground is unacceptable.

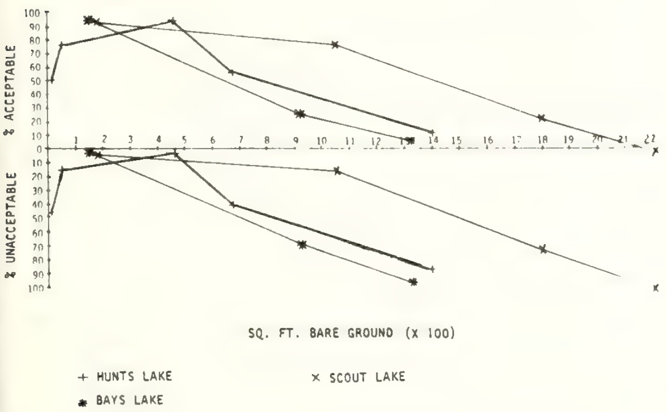

Figure 4.--Amount of agreement about standards for bare ground.

At Scout Lake, 78 percent agree that the amount of bare ground at the 1,050 square foot site is acceptable. For the 1,800 and 2,275 square foot areas, 70 percent and 90 percent agreed that the amount of bare ground is unacceptable.

It is interesting to note that very few people responded to impacts by choosing the "neutral" category. At one site, 9 percent used the neutral category. At the remaining 19 sites, 5 percent or fewer used the neutral category.

DISCUSSION

The first objective of this paper was to develop a method for collecting and organizing information about user evaluations of ecological impacts. The approach used here is based on prior work by Vaske (1978), Shelby (1981), and Shelby and Heberlein (in press). Although this previous work was aimed at establishing standards for social impacts in terms of encounters with other groups, it appears that the same approach can be used successfully for developing standards for ecological impacts. Users seem willing and able to evaluate conditions in terms of acceptability.

The approach used in the present study differs slightly from Shelby's (1981) work on encounter norms. The present study asked users to evaluate a set of specified conditions which were presented to them, while the earlier study asked users in an open-ended format to specify the highest acceptable impact. Whether the open-ended format should work for ecological impacts is an issue for further work.

The information on agreement about acceptability of impacts presented in figures 3 and 4 represents another change from previous work. Vaske (1978) and Shelby (1981) both address the agreement issue in terms of norm crystallization. However, crystallization is represented in this earlier work by the variance around the mean, a term with limited intuitive appeal for those with less statistical background. The present formulation has more intuitive appeal for managers, who can by interpolation use the figures to estimate the percentage of users who would agree about the acceptability or unacceptability of different impact conditions.

The second objective of this paper was to present data describing user standards in the Mt. Jefferson Wilderness. From a scientific point of view, one would like to develop generalizations based on the findings presented here, but there are two limitations on our ability to do so. First, Mt. Jefferson may not be typical of all wilderness areas; it is close to the population centers of the Willamette Valley and ranks second in Region 6 in visitor days per acre. Second, the study locations (Jefferson Park and Hunts Cove) are areas of fairly concentrated use around subalpine lakes. They are fairly typical of attractive destinations, but not all locations in the Wilderness. With these limitations in mind, some interesting speculations are possible.

First, wilderness users have opinions about impacts and are willing to express them. In this study virtually everyone avoided the neutral response category and took a position in evaluating impacts.

Second, norms or standards appear to be different for the different experiences offered by different locations. Acceptable levels for bare ground areas were considerably lower at both Bays Lake and Hunts Lake (in comparison with Scout Lake), and acceptable sizes of fire rings were smaller at Hunts Lake than at Russell Lake. Both Scout Lake and Russell Lake are heavily used camp areas immediately adjacent to the Pacific Crest National Scenic Trail. Scout Lake is the first obvious camp area for visitors entering Jefferson Park from the South, while Russell Lake is the first obvious camp area for visitors from the North. In contrast, both Bays Lake and Hunts Lake are a short distance away from the Pacific Crest Trail, and they receive less use. Users seeking out these areas are probably looking for a lower density experience. The point is that, even within the same general area of the same wilderness, there appear to be different norms or standards defining different experiences. Earlier work demonstrates this point by showing that users tolerate fewer encounters at camps than while traveling during the day on a river or trail (Stankey 1973, 1979; Shelby 1981). Shelby (1981) also demonstrates this point for different experience definitions (wilderness versus semi-wilderness or undeveloped recreation) in the same location. The present study extends this to different experience opportunities within the same wilderness.

Third, in some cases low to moderate impact may be more acceptable to users than no impact at all. There are at least two possible explanations. On one hand, some respondents may have felt that camping should be done at pre-existing sites, which are defined by areas of bare ground and evidence of previous campfires. A camp with no impact would thus be seen as undesirable because use would cause unacceptable change. On the other hand, it may be that users identify camps by the evidence of previous use (bare ground and fire rings), and these impacts, at least in moderation, actually increase the utility or desirability of camps. Other studies which have looked at physical characteristics of campsites have shown that campsite impacts are not a major influence on the choice of camps. Zuckert (1980) concluded that perceptions of resource overuse do not clearly influence the type of campsite chosen. Frissell and Duncan (1965) also concluded that campsite impacts did not influence a visitor's choice of camps. Merriam and Smith (1974) found that visitors seldom mentioned impact conditions at campsites, and Echelberger and Moeller (1977) had no mention of campsite impact conditions included in responses to a question dealing with most and least liked characteristics of the area. Taken together, these studies may suggest that managers should not make major commitments of resources to remove or prevent signs of low to moderate impact from camps, at least in heavily used camp areas.

Finally, data presented here show considerable crystallization of or agreement about impact standards. For 17 of the 20 sites studied, more than 70 percent agreed about the acceptability or unacceptability of impact, and agreement exceeded 84 percent at 10 of the 20 sites. If replicated in other settings, the amount of agreement found here could serve well as a basis for management direction.

ACKNOWLEDGMENTS

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REFERENCES

Brown, P. J.; Shoemaker, J. H. Final report on criteria for potential wilderness campsites. Logan, UT: Institute for Study of Outdoor Recreation and Tourism. Supplement No. 32 to 12-11-204-3; 1974. 50 p.

Dunwiddie, P.; Heberlein, T. A. Crowding and campsite selection at a high mountain lake. San Francisco, CA: 1975 Annual Meeting of the Rural Sociological Society; 1975.

Frissell, S. S., Jr.; Duncan, D. P. Campsite preferences and deterioration in the Quetico-Superior Canoe Country. Journal of Forestry. 63(4): 256-260; 1975.

Harris, C. C. Crowding in a wilderness setting: The influence of social interaction of users satisfaction. Fort Collins, CO: Colorado State University; 1978. Masters Thesis.

Heberlein, T. A. Density, crowding, and satisfaction: sociological studies for determining carrying capacities. In: Proceedings: river recreation management and research symposium; 1977 January 24-27; Minneapolis, MN. General Technical Report NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 67-76.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Miscellaneous Publication WO-1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Hendee, J. C.; Pyle, R. M. Wilderness managers, wilderness users: A problem of perception. Naturalist. 22(3): 22-26; 1971.

Hendee, J. C.; Harris, R. W. 1970. Foresters' perception of wilderness users attitudes and preferences. Journal of Forestry. 68(12): 7759-7762; 1970.

Lee, R. G. The management of human components in the Yosemite National Park ecosystem. Yosemite, CA: The Yosemite Institute; 1975. 134 p.

Lucas, R. C. Campsite impact perceptions. Review Draft; 1980. 19 p. Unpublished Study Plan.

Lucas, R. C. Perceptions of non-motorized recreational impacts: A review of research findings. Conference Proceedings: Recreational Impact on Wildlands. USDA Forest Service Report R-6-001-1979, PNW Region; 1979: 24-31.

Lucas, R. C. User evaluation of campgrounds on two Michigan National Forests. Research Paper NC-44. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1970. 15 p.

Merriam, L. C., Jr.; Smith, C. K. Visitor impact on newly developed campsites in the Boundary Waters Canoe Area. Journal of Forestry. 72(10): 627-630; 1974.

Peterson, G. L. A comparison of the sentiments and perceptions of wilderness managers and canoeists in the Boundary Waters Canoe Area. Journal of Leisure Research. 6(3): 194-206; 1974.

Public Law 88-555, The Wilderness Act. U.S. Statutes At Large. 890-896.

Shelby, B. Encounter norms in backcountry settings: studies of three rivers. Journal of Leisure Research. 13(2): 129-138; 1981.

Shelby, B.; Heberlein, T. A. Social carrying capacity in recreation settings. Corvallis, OR: Oregon State University Press; in press.

Shelby, B.; Harris, R. L. Techniques for measuring perceptions of ecological impacts at sub-alpine lakes. Corvallis, OR: Water Resources Research Institute; in press.

Stankey, G. H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 61 p.

Stankey, G.; McCool, S. F. Carrying capacity in recreational settings: Evolution, appraisal, and application. Leisure Sciences. 6(4): 453-474; 1984.

Vaske, J. J. Contact preference norms versus actual contacts: Crowding among Brule River canoeists. Paper presented at the Annual Meeting of the Rural Sociological Society, San Francisco, CA; 1978. 26 p.

Zuckert, J. A. Environmental and psychological determinants of campsite selection at a high Sierra Lake. Fort Collins, CO: Colorado State University; 1980. 72 p. Masters Thesis.

Section 4. Wilderness Fish and Wildlife Research

A NEED FOR FACTS AND COMPROMISE

Robert G. Streeter
Session Coordinator

Wilderness, with its fish and wildlife resource values, like the arts presented in theater, literature, and graphic forms, is an accepted component of a rich and full society. On the "Old Frontier," there was a need and philosophy of conquering wilderness. However, it has been said that the biggest challenge of the "New Frontier" is to conquer civilization.

Our western civilization places many demands on available resources, including the fish and wildlife resources in wilderness environments. To "conquer" this civilization, and the conflicts of competing demands on our resources, there is an increasing need for factual information. There is a need for understanding of the facts and for compromise decisions that provide long-term benefits to our civilization.

The following papers are in two segments. The first four papers form an example of the complex world of managing fish and wildlife resources. The biological facts for a representative wilderness species are presented by Dr. Servheen. Dr. Ream exposes us to one aspect of the political facts, the real world of State and Federal legislative decisions--decisions that will determine legal frameworks for managing wilderness species. The third perspective is the one of competing values. Poet-author McNamee articulates the values of managing wilderness to preserve a species. Ms. Anderson, also representing the views of resource users, proposes a compromise position of balancing competing resource values and users.

Discussions generated by the first four papers, which were presented in a panel format, provided graphic evidence that biological facts often fade in significance relative to the political process and to competing, often directly conflicting, resource users. The message to wilderness researchers is to identify fuzzy issues involved in such conflicts, to focus objective studies on the factual aspects that might bear (pardon the pun!) the greatest impact on resource management decisions, and to ensure that the facts are presented in a timely manner, in a usable format, to the appropriate persons in the decision process.

The second segment of the session papers presents three distinctly different examples of scientific approaches focused on critical management issues with results that are making a difference in management decisions. Endangered fisheries researchers Haynes and Bennett relate how the complex and difficult interagency studies of the endangered Colorado squawfish provide quantitative results that specify the critical habitat features of the upper reaches of the Colorado River system. This information is critical to pending decisions on water development projects. Creative research on wildlife-human interactions, presented by Dr. Graber, provides insights to the basic causes of such a conflict and forms a basis for local management actions to minimize future conflicts. In a novel use of data summaries from a basic, experimental research study, Ms. Krueger provides an objective, factual basis for practical management recommendations of both wildlife-wildlife and wildlife-human interactions.

These scientific papers are unique and should set a standard for all wilderness researchers and managers in the planning and conduct of wilderness research and in the application of research findings to the wilderness management of fish and wildlife resources.

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BIOLOGICAL REQUIREMENTS OF A WILDERNESS SPECIES

Christopher Servheen

ABSTRACT: The grizzly bear (Ursus arctos horribilis) has often been considered the prime example of a wilderness species. Two factors, the spiritual and biological, combine to define the connection between the grizzly and wilderness. The spiritual basis for the consideration of the grizzly as a wilderness species is the aura of remoteness and wildness associated with this dominant large carnivore, which is one of the few animals in North America to sometimes prey upon man. The biological characteristics of the species associated with wilderness include the need for a very large home range size and a diversity of foods, ability to utilize almost all available plant communities and elevational ranges, and the bear's pugnacious and opportunistic behavioral nature, which sometimes results in aggressive competitive interactions with man. This paper outlines these biological characteristics that define the grizzly as a true wilderness species.

INTRODUCTION

The biological attributes of a true wilderness species can be defined as those which necessitate large areas of relatively pristine and intact habitat for the species to prosper. Within these large areas, the species has a limited tolerance for excessive human environmental impacts. The potential for significant competition and interaction between the species and man should be minimal. The long-term existence of a true wilderness species will often be tied to the existence of areas that maintain many of the environmental attributes that the animal has evolved to exploit. In addition, the maintenance of true wilderness species populations must be tied to the recognition that human use, even in a non-consumptive fashion, is an effect on these areas.

The adaptability and corruptability of the behavior and habitat use of a species in the presence of man, and man's reaction to the presence of the species as it adapts to a human environment, determine if the animal is indeed a true wilderness species. A high level of adaptability of a species to a human-influenced environment such as that shown by the white-tailed deer (Odocoilious virginianus) or the red-tailed hawk (Buteo jamacanensis) is one indicator of a non-wilderness species.

Another key to a true wilderness species is the reaction of man to the presence of the species if it tries to adapt to human environments and thus begins to live in close association with man. Non-wilderness species are tolerated (i.e. the red-tailed hawk) while others are not only tolerated but managed specifically to live in human-influenced habitats (i.e. the white-tailed deer). While some species, such as caribou (Rangifer tarandus), are not able to live in strongly human-influenced environments but would probably be tolerated, others such as the grizzly bear and the wolf (Canis lupus) could live quite successfully in close association with humans but are not tolerated. Thus, a wilderness species must either be unable to live in human-influenced environments or it must not be tolerated by man when it is in close association, or both. Using this definition, then, the grizzly bear is a true wilderness species because, although it is capable of living in close association with man, most people are intolerant to the close association of bears.

The biological attributes which characterize the grizzly bear and the characteristics of the areas in which the species still prospers fundamentally link the species to wilderness. These species' attributes are essentially the behavioral and ecological nature of the animal as molded by its evolutionary response to its environment.

SPACE

Space can be defined as the area available within the conterminous landscape in which the activities of the species are not constrained. The grizzly bear's need for space is closely tied to its large home range size. The home range of typical adult females may be between 250 and 1000 square kilometers while that of typical adult males may be between 750 and 2500 square kilometers. Thus, the home range size per grizzly bear is one of the largest of any land mammal in North America. The concept of space does not only include the extent of habitat; the habitat must also be available for use. This combination of presence and availability defines habitat effectiveness. The effectiveness of the space available to the bear can be assessed by the habitat characteristics of the area and the quantity of human-related actions that limit or inhibit movement and natural behaviors within this habitat.

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FOOD DIVERSITY AND HOME RANGE SIZE

Another important biological attribute of the grizzly is its dependence on a diversity of foods. The grizzly is an opportunistic omnivore that uses a wide range of foods, many of which are only available seasonally. The grizzly, in many areas, is an altitudinal migrant due to its preference for certain foods at certain elevations at different times of the year.

Approximately 80-90% of the diet of the grizzly is vegetation, and yet, the grizzly does not have a specialized digestive system to digest cellulose as do most herbivores. When grizzlies eat considerable amounts of green vegetation, they are not able to efficiently absorb nutrients. The majority of the weight gain that grizzly bears obtain from vegetation comes from starchy tubers, sweet fruits from shrubs, which are rich in sugars, and cones of certain conifer species, which are high in fats. Of these important plant species, fruit-bearing shrubs and cone-producing conifers are not an annually reliable food source. Often, the distribution of productive shrubs and cone-producing conifers is patchy within the environment or varies annually depending on environmental conditions.

Patchy food distribution and the variable nature of the production of certain foods makes these resources unpredictable in space and time in the environment. This unreliability of resources is essentially unpredictable to the bear. The probability of any given area having sufficient numbers of productive food patches at any one time is a function of the size of the area. Thus, to a certain extent, bears have compensated for resource unpredictability through large home range size. Large home range areas often contain a sufficient number of patches of various foods so that the probability of productivity within at least some of these patches in any one year is fairly high. A large area is required to produce a reliable amount of these important foods in any given year. A diversity of habitat probably is a major contributor to the ability of the environment to produce foods consistently.

SOLITUDE

Another attribute of the grizzly bear that is directly related to wilderness is its need for solitude. Solitude can be defined as the absence of disturbance from human activities. Grizzly bears have a complex social system that allows interactions between individuals at sites of food concentration, and bears are also characterized by long-term mother-offspring relationships. Social interactions are perhaps the most vulnerable portion of the grizzly bears life history to human disturbance. Human activities have the potential to disrupt social interaction between individuals by causing them to leave certain areas, to disperse, and to interrupt behavioral interactions. Female grizzly bears with cubs often inhabit remote areas away from the presence of other bears in order to maximize safety for their offspring and probably to facilitate undisturbed mother/young interactions. In the presence of people, females with cubs either flee or, when approached too closely or surprised, can react aggressively. Thus, female bears with young seek solitude from other bears, and the presence of people can often be as disruptive and dangerous to them and their offspring as other bears. Wilderness areas where human presence is not continuous and where human activities are somewhat predictable in space and time may offer solitude for grizzlies while areas of permanent human occupation and intensive use preclude any semblance of solitude.

Another aspect for the need of solitude for grizzly bears is the habit of denning in the wintertime. Grizzly bears enter a den for up to 5 months and remain in a state of hibernation. During this time, bears are still susceptible to disturbance. It has been shown that grizzlies will respond to wintertime disturbance outside the den through increased movement and heart rate while in the den (Reynolds and others, in press). Grizzly bears are very sensitive to human disturbance at the time they are selecting and excavating a den and will abandon a site or even an excavated den if disturbed by humans prior to final entry (Craighead and Craighead 1972).

Most grizzly bear den sites are on steep slopes above 6,500 feet, but in some areas they can occur in forested or open-forested habitat. Motorized winter recreation in such areas can be a potential disturbance and could cause den abandonment and disruption of reproduction. Females have their young in the den in midwinter, and physiological stress may result from a higher level of wakefulness within the den during the period of the disturbance. These potential effects of human disturbance highlight the need for solitude for this species.

BEHAVIOR IN THE PRESENCE OF HUMANS

Another biological attribute of the grizzly bear that is directly related to its status as a wilderness animal is its behavioral corruptibility in the presence of man. Grizzly bears are long-lived, intelligent, and opportunistic. They have the ability to take advantage of any available food source within their environment. They can and will utilize unsecured human foods that they find within their range, and they will develop behavior patterns to utilize such foods once they have been successful in exploiting them. Thus, the behavior patterns of bears can rapidly change from a "wild" animal to one that is closely associated with humans by seeking out human use areas as feeding sites. Once bears have successfully exploited human foods, they will usually continue to seek out these foods. The possibility of changing their behavior once they have received such a positive reward is remote.

Predictable human food availability at established development areas has been the prime source of human/bear conflicts in the lower 48 states. Considerable efforts have been exerted by Federal and State agencies to minimize the availability

of food at such sites. Still, even after human foods have been secured at such sites, their prior predictable presence induces positively conditioned bears to investigate them and often come into conflict with man. In wilderness areas, backcountry users too must secure their human foods and other attractants such as game meat from bears, or the same type of corrupting influences will occur. Wilderness areas have a high potential of maintaining grizzly bears solely on naturally occurring foods if wilderness users maintain secure campsites.

DENSITY

Viable grizzly bear populations require large contiguous areas that meet the biological needs of existence. The grizzly bear is a large carnivore, and most large carnivores have a low population density. Exceptions can occur where foods are highly concentrated and predictable in space and time, such as in southeast Alaska. These areas can support much higher population densities and smaller resultant home range sizes because of the amount and predictability of food resources. In most interior Rocky Mountain areas, grizzly bear densities are low because foods are not predictable in space and time resulting in large home ranges so the animals can gain knowledge of the food distribution within a wide area. With this low population density, a large area is necessary to maintain a minimum viable population. A minimum viable population is defined as the minimum number of bears within a closed population which has a 95% probability of survival over 100 years (Shaffer 1980). This low population density that results in a large area necessary to maintain a minimum viable population also requires that the area have the characteristics discussed earlier of space, diversity of natural foods, and solitude. Thus, large areas of suitable habitat are necessary to maintain enough animals for a viable grizzly bear population.

BEHAVIOR

Grizzly bears have an aggressive nature, which may have originated with their adaptation to open, treeless habitats after the retreat of the glaciers (Herrero 1978). This aggressive nature is manifested in an intolerance to any species that may present a threat. The grizzly bear is often characterized as an animal that is aggressive to people. These aggressive incidents result when bears and people occupy the same habitat. It has been demonstrated that human/bear encounters resulting in human injury are directly related to visitor use within grizzly habitat (Martinka 1982).

Aggressive encounters between grizzly bears and people can be characterized as either natural aggression or unnatural aggression. Natural aggression is either: 1) a bear protecting a food source; 2) a female protecting her young; or 3) a bear surprised at close range. Unnatural aggression usually consists of a bear approaching people and actively pursuing them or entering a campsite and attempting to attack a person.

Natural aggressive incidents are often directly related to the number of people encountering bears. Thus it follows that areas with limited human use, or predictable human use resulting in habituation (Jope 1985) will have fewer naturally aggressive encounters between bears and people.

THE RELATIONSHIP BETWEEN GRIZZLY BEARS AND WILDERNESS

The nature of the grizzly bear as an animal which requires significant amounts of space, solitude from excessive human disturbance, and a broad range of diverse and available habitats, makes it a prime example of a wilderness animal. Other biological characteristics of the species associated with remote areas are its ability to be behaviorally corrupted with human foods, its low density which requires large areas of necessary habitat, its ability to compete directly with people both for resources and space, and its low tolerance for humans, which is often manifested in direct aggression. Wilderness areas have a major role in the preservation of the species because they have the potential to provide many of the attributes necessary to meet the needs of the grizzly bear. Areas under intensive human development and/or continuous habitation have a lesser ability to meet these needs than those areas under a special management such as wilderness. The long-term survival of the grizzly bear will depend upon the maintenance of wilderness areas and adjacent habitat where the bear now exists so that these areas not only exist, but that they continue to meet the biological needs of this true wilderness species.

REFERENCES

Craighead, F.C.; Craighead J.J. Grizzly bear prehibernation and denning activities as determined by radio-tracking. Wildlife Monograph 32: 1972. 35 p.

Herrero, S. A comparison of some features of the evolution ecology, and behavior of black and grizzly/brown bears. Carnivore. 1(1): 7-17; 1978.

Jope, K.L. Implications of grizzly bear habituation to hikers. Wildlife Society Bulletin. 13: 32-37; 1985.

Martinka, C.J. Rationale and options for grizzly bear sanctuaries. Trans. North American Wildlife and Natural Resources Conference; 4: 470-475; 1982.

Reynolds, P.E.; Reynolds, H.V. III; Folman, E.H. Effects of seismic surveys on denning grizzly bears in northern Alaska. In: Proceedings, Sixth Conference on Bear Research and Management; Grand Canyon, Arizona; 1983. In press.

Shaffer, M.L. Determining minimum viable population sizes: a case study for the grizzly bear. Durham, North Carolina: Duke University; 1978. 142 p. Ph.D. dissertation.

THE POLITICAL ENVIRONMENT FOR MANAGEMENT OF A WILDERNESS SPECIES

Robert R. Ream

ABSTRACT: Management of wilderness species may be more dependent on the political environment than on any manipulation or management of the natural environment. Management is determined or influenced by legislation, administrative rules, management plans, and last but not least, by budgets. These same factors enter into management decisions at the state level as well as the federal, making management of threatened or endangered wilderness species even more complex, particularly with species as controversial as grizzlies or wolves. Researchers and managers of wilderness species must put a considerable amount of effort into working with and educating constituents in and out of government. Wolves are the only large predator that are listed as endangered, therefore presenting a unique challenge to managers, researchers, and legislators, at both the state and federal level.

INTRODUCTION

In this paper I will try to bridge the gap between the two professions or lives I currently lead. First, I am an ecologist by training and have been on the faculty of the School of Forestry, University of Montana since 1969. Second, since January 3, 1983, I have served in the House of Representatives of the state of Montana. What is the relationship between the two? Why would I leave a comfortable faculty position, and traipse off to the state capitol every other year to serve in a legislative session for 90 days? Although I've been asked that question many times, it's a difficult one to answer, because many factors certainly entered into the decision.

Perhaps Aldo Leopold answered it best for me in the last paragraph of his essay "Thinking Like a Mountain"

> "We all strive for safety, prosperity, comfort, long life, and dullness. ..... A measure of success in this is all well enough, and perhaps is a requisite to objective thinking, but too much safety seems to yield only danger in the long run. Perhaps this is behind Thoreau's dictum: In wildness is the salvation of the world. Perhaps this is the hidden meaning in the howl of the wolf, long known among mountains, but seldom perceived among men." (Leopold 1949).

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I believe that Leopold was suggesting that we have diversity in our lives and our professions as well as in ecosystems.

At any rate I ended up in the wilderness of the state capitol, a greenhorn with perhaps too much education, 46 years old, and enough shyness to keep me from getting into trouble right off the bat. As in almost all wilderness experiences I've had, I learned a lot the first time around, and went back for a second. In serving, I agreed to uphold our constitution, which has a preamble that states:

> We the people of Montana, grateful to God for the quiet beauty of our state, the grandeur of our mountains, the vastness of our rolling plains, and desiring to improve the quality of life, equality of opportunity and to secure the blessings of liberty for this and future generations do ordain and establish this constitution.

This constitution, written in 1972, and the corresponding U.S. Constitution form the basic framework and laws for the state and federal governments. Although constitutions are only changed occasionally, statutory laws are changed or added every time congress or state legislatures convene. Finally, case law is established when conflicts arise and interpretations of constitutional and statutory laws are made by the courts.

COMPONENTS OF THE POLITICAL ENVIRONMENT FOR MANAGEMENT OF A WILDERNESS SPECIES

Components of the political environment can be separated out and examined, like habitat components, or components of the biological environment of a wilderness species. There are four major factors or components that must be considered part of the political environment of a wilderness species. First, legislation that establishes wilderness, or endangered species, for example, is the most basic component. Second, legislative bodies also give rule-making or regulating authority to the executive branch of government. Third, agencies establish management plans, such as land use plans or recovery plans, where political considerations are very important. Finally, budgets to carry out laws, regulations, and management of resources are established by legislative bodies. Each of these factors is subject to political considerations and all are subject to the various public bodies that are affected by decisions. Like ecological factors, these are interrelated, and seldom can one stand alone.

Legislation

The first important factor in the political environment of a wilderness species is statutory law, or legislation. That is not to say that constitutional law or even case law are not subject to politics, but constitutions only set a broad framework and they are changed very infrequently. Case law may be affected over time by the makeup of the courts, but it too changes relatively slowly, and the job of the courts is to interpret legislation and constitutions. Congress is in session every year and meets most of the year, and it could change legislation fairly readily if it needed to. Similarly, most states have annual legislative sessions, and in the more populous states those sessions last most of each year. In Montana, however, we meet every other year starting the first Monday in January, meeting 6 days a week for 90 legislative days, then we're done and go home, and department heads breathe a sigh of relief! I found it to be a very intense, very demanding, and yet very exhilarating experience, unlike any other I have had to date.

Not all agency people will be able to participate in the legislative process as I have done, but believe me, the legislative process needs you. It needs the benefit of your knowledge and experience. Legislation, either good or bad, doesn't just happen. Someone proposes it, and there are proponents and opponents (seldom just ponents), and ultimately legislators must make a decision based on the best information and advice available to them. (I'll use the term legislator throughout this paper to refer to senators, representatives, delegates, congressman, or any other title given lawmakers.) I know that many of you, as federal employees, are not allowed to participate in the legislative process, or even in the electoral process(except to vote). You can only respond to questions from legislators. It is sad that agency employees are disenfanchised like that in our democracy, but it isn't hopeless. See to it that you are asked the right questions. You probably will be if legislators are aware of your work or if your constituent groups are fully aware of what you are doing and have the right information to use at the appropriate time. And whatever you do, don't tell me you don't have a constituent group! You are only deluding yourself if you actually believe that, and your program will not last, no matter how good you think it is. Last April, after I came back to campus from the legislative session, one of my colleagues said "Well, how is it being back in the real world." I said "Well, I left the real world there, and came back to campus." The legislative halls are the real world in terms of setting policy for government, making laws, and establishing budgets. It is best to recognize that early.

Tom Kimball, former director of the National Wildlife Federation, stated "The legislative process is often cumbersome and unwieldy; yet, when practiced properly, it provides for honest, sincere, and comprehensive review of laws, rules and regulations with which the public will be saddled. It appears inevitable that more and more laws will be enacted as the result of stresses and strains developed by conflicts within an expanding human population." (Kimball 1971). It appears inevitable to me, that the stresses and strains on natural resources will be at the head of the list and that legislators will need the help of resource managers and researchers even more in the future. They can help by providing advice and information so that sound decisions can be made.

Individual legislators are faced with a nearly impossible task. We simply cannot fully understand and pass judgment on every bill that comes our way--on taxes, labor, fish & wildlife, education, judiciary, coal mining, railroads, or women's issues. So, we rely heavily on each other and on the committee system. Between January 6th and April 24th, 1985, in Montana's capitol, we introduced 1543 bills, held hearings on them, voted on them, transmitted most to the other house where additional hearings were held and votes taken, resulting in 836 bills being passed by both houses and signed by the governor. The committees are the most critical point for influencing legislation and the place where a major part of the work is accomplished, particularly public hearings and gathering of additional information from various experts. You are the experts in those areas you are familiar with and constituent groups are your advocates. Many constituent groups have lobbyists, and lobbyists are people that have the facts, at least if they are successful in their work.

After serving two sessions in a state legislature I am much more pleased and confident that our democratic process, though cumbersome and inefficient, really is government of the people, by the people, and for the people. I found farmers, lawyers, carpenters, ranchers, doctors, railroaders, teachers, nurses, retirees, and students, people from all walks of life. It works, but it will only work if people make it work. As resource managers and researchers you must help make it work. In this country we enjoy many rights. "In enjoying these rights, all persons recognize corresponding responsibilities."(Art. II, Sect. 3, Montana Constitution). Those responsibilities include participating in government. Earlier in these proceedings, Harry Crandell stated that Congress is not an initiating body, and it is not a decision-making body. He stated that it is a reactionary body. It reacts to the will of the people.

Administrative or Executive Rules and Regulations

The legislative branch of government delegates certain rule-making powers or authorities to the executive branch. They often establish a policy-making board or commission to approve of those rules or regulations. For example, state fish and game departments recommend hunting and fishing regulations for approval by a fish and game commission. This then, is obviously part of the political environment for management of a wilderness species. "Most commissioners are non-salaried and nearly all are politically appointed. In a real sense, they are small legislatures responsible to the people for the well-being of public resources." (Towell 1971). Thus, like legislation, there are opportunities for the public to influence the decisions made.

In nearly all cases, the rule-making process involves public hearings and/or other ways of accepting public input. It is very important that the public be involved in this process. Since the draft rules or regulations are usually drawn up by an executive branch agency, many of you have probably helped draft such rules, whether it was for the Code of Federal Regulations, the Forest Service Manual, Endangered Species listings, or state rules. These have the force of law and, as with statutory law discussed earlier, it is important to communicate with all constituents. Again, you have a responsibility here, either directly, or through constituent groups.

Management Plans

The management plan component of the political environment is the part that the majority of you are most familiar with. You have probably all been involved with land use plans, recovery plans, wilderness management plans, or other types of plans that bring management of the resource right down to the ground level. In so doing, you obviously are making political considerations, because you undoubtedly are affecting someone. Public hearings and public involvement are extremely important at this step, because this is the step that is closest to the resource.

Sometimes informal or formal advisory boards or councils are used by managers, not only because they are people that are directly involved and probably know the resource problem very well, but also because they are then involved in the decision-making process and feel a part of it. Thus, agencies sometimes appoint citizen's advisory groups to help draft up wilderness management plans. Recovery Teams have been appointed by the U.S. Fish and Wildlife Service to develop recovery plans for each endangered species.

It is important to note that with both management plans and administrative rule-making, legislators may intercede and pass laws or amendments that may completely change the rule-making process or boards or management plans. This intervention is bound to happen if citizen advisory boards are only used in a token way, if administrative rules are inconsistent or unclear, or if they contradict legislative intent. For example, management is sometimes dictated by legislation or a legislative statement of intent, for better or for worse. In wilderness management, recent legislation in Colorado and Idaho has dictated procedures and techniques to be used in managing grazing in wilderness bills. Numerous other examples can be found.

Budgets, or The Squeaky Wheel Gets the Grease

Times are tough and budgets are tight. Money isn't just appropriated out to whoever happens to be a nice wilderness manager or a researcher who very dutifully does his or her thing. Legislators not only pass legislation as discussed above, they also have the responsibility of developing budgets to run government <u>and</u> finding the sources of revenue to fund those budgets. Many seem to forget that connection. I've had people come and ask me to support an increased budget for this or demand an adequate budget for that. When asked where we should get the money for that fine program, they say "That's your problem." It's their problem as much as it is mine as a legislator. Are they willing to go out and actively support an increased income tax, or property tax, or will they promote an increased hunting license fee to support mountain goat management?

The point here is that if you don't have constituent groups or users going to bat for your program, it will cease to be funded after a period of time. It's that simple. You must document very carefully how the money will be used and why it is needed. Constituents as well as legislators must understand that. The four components discussed here are, of course, interrelated, but without funding for a program, legislation, rules and particularly management plans may be only so much paper.

MANAGEMENT OF A WILDERNESS SPECIES

Two wilderness species, and the two threatened and endangered species that present the greatest challenges to managers because of their political environment are the grizzly bear and the wolf. The paper preceding this and the one following, deal with grizzly bears. The word wolf could be substituted for grizzly through both of those papers because of the similar reasons for their threatened and endangered status. Both were exterminated from Colorado and most of the west because of human attitudes and use of poisons. Even in Glacier and Yellowstone National Parks, rangers were trying to get rid of wolves as late as 1933, by lacing animal carcasses with strychnine poison. Grizzlies undoubtedly died in the process. Recovery areas identified for both species nearly overlap, and include mostly wilderness. There are a few notable differences that make wolf recovery different than that for grizzly bears:

1. Wolves aren't known to kill humans, whereas there have been several grizzly-caused human mortalities.

2. Wolves are more predatory and will undoubtedly cause more problems with livestock than grizzlies. They are strictly carnivores.

3. Wolves are a more social animal; they hunt and live as packs, perhaps making them more vulnerable to humans. (Wolves also sing together instead of just grunting or bellering by themselves.)

4. Grizzly bears hibernate 5 months each year, whereas winter is an active time of year for wolves. (Wolves aren't as lazy!) In winter, wolves are probably most vulnerable to humans killing them.

5. Wolves have a much higher reproductive rate than grizzlies. They reach breeding age at 2 years and have litters of 6-8, though only the dominant male and female in a pack will breed.

6. Wolves are classified as endangered, except Minnesota populations, whereas grizzly bears are classified threatened.

I will say a few words about the political environment for wolves. The biological environment for wolves is outstanding in Glacier National Park, where I am conducting research on wolves, and particularly in Yellowstone National Park, where they have ungulate prey species coming out of their ears, or at least out of their park. The political environment for wolves and wolf recovery is not nearly as outstanding.

Let's look briefly at the four components of the political environment I talked about earlier, in terms of the wolf. We must consider both the federal and state political environment.

Legislation - Northern Rocky Mountain Wolf

Threatened and endangered species were afforded federal protection with passage of the Endangered Species Act in 1969 and amendments in 1973. Not only does the act prohibit killing or taking of endangered species, it also provides that federal agencies shall adopt programs to enhance recovery and prevent loss of critical habitat. Some states consider this a state's rights issue, and view the Act as taking away their jurisdiction to manage these species. Some states, including Montana, have listed the wolf as endangered, while in Wyoming, the wolf is still listed as a predator. Montana has an endangered species act with a listing procedure, but in this case the listing must be approved by the legislature. During the 1985 legislative session I sponsored a bill to approve the White Sturgeon as an endangered species in Montana. Although it passed second reading in the House, the following day, the word being passed down the aisles was "Remember the snail darter!", and it was defeated.

Rule Making for the Northern Rocky Mountain Wolf

The U.S. Fish and Wildlife Service listed the Northern Rocky Mountain Wolf subspecies, *Canis lupus irremotus*, as endangered in 1973, and in 1978 the Gray Wolf species, *Canis lupus*, was listed as endangered in the lower 48 states, except in Minnesota where it was listed as threatened. The framework for listing, downlisting, or delisting individual species is established by the Endangered Species Act, but the process itself can be a very political one. With the 1978 rule making for the Gray Wolf, it was downlisted to threatened in Minnesota. Some federal legislators, unhappy with the rule making process, have tried at times to repeal the Act or gut the process.

Management Plans for the Northern Rocky Mountain Wolf

The U.S. Fish and Wildlife Service appointed a Northern Rocky Mountain Wolf Recovery Team in 1974 and the team produced a Draft Recovery Plan in January, 1978. It was approved by the Director in May, 1980. The recovery plan provides the overall framework for wolf recovery. During 1983, the team worked on drafting wolf management guidelines to aid federal land managing agencies, which were mandated to enhance recovery and prevent loss of critical habitat. A rough working draft was reproduced and distributed to numerous people by livestock interests, and such a furor was created that several congressional hearings were held in Idaho that summer. The team then revised the original recovery plan and the revised draft has yet to be approved by the Director of the U.S. Fish and Wildlife Service. Besides outlining procedures to attain recovery, the plan assigns responsibilities for various actions to state and federal agencies. The revised draft plan also recognizes that recovery can only be attained in a small part of the former range of the wolf. The three recovery areas proposed are all largely wilderness lands, while all the rest of the former range is largely agricultural land. The draft plan makes provisions for taking wolves on those agricultural lands, a proposal that will be controversial and political, but necessary I believe, if we are to have wolves in the wilderness portions of the area.

Budgets - Who Will Pick Up The Tab?

Section 6 of the Endangered Species Act provides for a cooperative funding effort between the federal government and states, for management and research. Funding for wolf management and research must compete with all the other endangered species and is of course limited. States are reluctant to fund management of a species that is listed by the federal government. Some states, including Montana, fund nearly all wildlife management and research through sportsmen's dollars. With a species as controversial as the wolf, would you be willing to use sportsmen's dollars to fund wolf management if you were Director of a state wildlife agency? More importantly perhaps, if the wolf were to huff and puff and blow your house down, who should pick up the tab for the damages? The wolf is the only major predator that is also an endangered species, the only one capable of killing domestic livestock. Minnesota's legislature passed a livestock compensation bill to reimburse farmers for livestock killed by wolves. This should not be a state responsibility, since it is federal policy to attain wolf recovery. Many wildlife professionals are fearful that any kind of reimbursement for livestock killed by wolves will open Pandora's box for all sorts of other reimbursement programs. That is possible, but I believe there is a major difference between endangered species and other species. The important thing here is to have a good control program in place before recovery occurs, so that wolves can and will be taken in agricultural areas and the need for reimbursements can be avoided or diminished. Such a control program must be funded, and funding to monitor the status and distribution of wolves must parallel that needed for control.

THE WOLF IS AT OUR DOOR

Wolves appear to be making a comeback in the area of Glacier National Park and the Canadian border (Ream and others 1985; Ream and Mattson 1982). If recovery is to occur, the political environment must be taken care of. The above components are complex and interrelated, and altogether present a political hot potato. We must learn as we go; we will need facts, and we will need understanding among the interested groups and agencies. Wolves are held in the public trust by the Endangered Species Act, but they may infringe on private rights, and thus we have a classic but common resource management problem. As Leopold stated, "Only the mountain has lived long enough to listen objectively to the howl of a wolf." (Leopold 1949).

REFERENCES

Kimball, T.L. The legislative process. In *A Manual of Wildlife Conservation*, The Wildlife Society, Inc., Washington D.C., 1971.

Leopold, A. *A Sand County Almanac*. Oxford University Press, 1949.

Ream, R.R. and U.I. Mattson. Wolf status in the northern Rocky Mountains. In F.H. Harrington and P.C. Pacquet (Ed.), *Wolves of the World*, Noyes Publications. Park Ridge, NJ, 1982.

Ream,R.R., M.W. Fairchild, and D. Boyd. *Wolf Ecology Project Annual Report*. Technical Report, School of Forestry, University of Montana, 1985.

Towell, W.E. Role of policy making boards and commissions. In *A Manual of Wildlife Conservation*, The Wildlife Society, Inc., Washington D.C., 1971.

ALL FOR ONE AND ONE FOR ALL:

THE PARADOX OF SINGLE SPECIES MANAGEMENT

Thomas McNamee

ABSTRACT: What has worked in the past in grizzly bear management will no longer work today, and what we have thought worked in the past may really not have been working at all. The cost of grizzly bear recovery in the lower 48 United States need not be terribly high, and the benefits, although some of them may not be quantifiable, will be very great.

The poor old grizzly bear. Rarely has any single wild animal been asked to shoulder so much of the weight of what we mean when we say "wild." Rarely has any single creature endured such antagonism from so many and such violent human enemies. And rarely has any single species been asked to symbolize wilderness for so many and such passionate human advocates.

At least in the lower 48 United States, it isn't easy being a grizzly bear. For a very few grizzlies, I suppose, up in the remotest berry patches of Glacier Park, where grizzly home ranges are small and relatively undisturbed, one's kingdom can be pretty much one's own. But for most of the Lower 48's grizzly bears, life is one continuous sort of obstacle course.

My particular interest has been in the world-famous grizzlies of the Yellowstone ecosystem, whose course in recent years has been especially well furnished with obstacles. It was never particularly easy being a grizzly in a place like Yellowstone. The climate has always been wildly variably, and in response to it the availability of grizzly plant foods, animal prey, and carrion is equally so. Primeval Yellowstone droughts and bitter late spring frosts must surely have played havoc with even the earliest populations of Yellowstone grizzlies, long before ski resorts and high-powered rifles and Compound 1080 put in their appearance. Compared to the great lowland wildernesses of the intermountain West where grizzlies once thrived, or to coastal California or southeast Alaska, Yellowstone is rather lousy grizzly habitat.

Yet Yellowstone is one of only three ecosystems in the Lower 48 where significant grizzly populations have survived. The reasons for that survival, and the question of its ability to continue, bring us squarely face to face with the topic of this discussion.

The usual definitions of wilderness almost always include something about minimal human influence. But Yellowstone tends to confound the usual definitions, for it has suffered the careful and the careless manipulations of its stewards, and the burgeoning influence of its visitors, for more than a hundred years, and yet, to most of us, it still seems pretty wild. We may say, perhaps with some circularity, that one reason why it feels so wild is that there are still grizzly bears there, and the fear, or at least hyper-awareness, which those grizzlies elicit in us is certainly part of what we feel as the experience of wildness. The fact that Yellowstone, for all its apparent wildness, does not have that history of human non-use which we usually consider essential to the idea of wilderness has often been put up on bold display by those who would claim that grizzly bears and intensive human use can be perfectly compatible.

Let's not forget, however, that the grizzly bear in Yellowstone and elsewhere in the Lower 48 is listed as threatened under the Endangered Species Act, and that the future of these populations is very much in question. Nevertheless there are still grizzly bears in Yellowstone, and in most other historic grizzly range there are not. Why? Let's think about the nature of the human uses historically made of grizzly habitat in the Yellowstone ecosystem. It seems to me that three factors are of particular importance.

First, most of the human use has been nonconsumptive, or if not, it has at least been closely confined in time and space (like a hard-rock mine, say) and resource consumption has been minimal.

Second, one human use, namely the dumping of edible garbage, for many years had a strong stabilizing effect on the nutrition of many Yellowstone grizzlies. Garbage-feeding also habituated grizzlies to human presence, overcoming much of their natural inclination to avoid people.

And third, there is a long time lag between the beginning of a negative influence and its measurable effect on a grizzly bear population. Adult grizzlies are quite long-lived, provided that people don't kill them; they may not reach senescence until they near 30 years of age. Yellowstone grizzlies do not breed until they are six to eight years old, and they bear an average of fewer than two cubs per litter about once every three years. With such a low reproductive rate, in which moreover only a few

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of the adult females carry the burden of producing most of the young, grizzly populations are extraordinarily sensitive to mortality. And yet--and this is the most important point, which land managers far and wide continue to duck--you may not know that a population is in trouble until it has already been in trouble for years. Grizzly population data are notoriously hard to get, and the only realistic way to assess them is over the truly long term. And we all know how impatient managers are for conclusions. And we all know how researchers somehow produce those conclusions even when they're really not at all sure of them.

From these three points, then, we can draw three tentative suppositions: one, that there are certain kinds of uses that a grizzly population can stand; two, that the only way Yellowstone's grizzlies have managed to survive is because they were artificially fed; and three, that Yellowstone's grizzly population may in fact not have stood those nonconsumptive uses at all, or it may not have been able to stand the loss of the garbage dumps that were closed in the late 60s and early 70s, and it may, for one or more of those reasons, already be doomed.

Now let's examine those suppositions.

The first is already being widely tested--indeed, pushed to the limit--in the five national forests that ring Yellowstone National Park. An impressively fat document called "Guidelines for Management involving Grizzly Bears in the Greater Yellowstone Area" is one of the most ambitiously detailed wildlife management plans ever written, and in conjunction with the Grizzly Bear Recovery Plan it is regarded as essential to grizzly recovery in Yellowstone. Whether it will be sufficient seems to me questionable. In page after page of this document, procedures are laid out for protecting grizzlies in almost every imaginable use of the land. How to run a timber sale...how to manage hunting camps...garbage disposal...seismic exploration...nuisance bears ...forest fire...you name it, it's here. And for the most part these guidelines are terrific--sensitive, sensible, and strong. They even allocate vast acreage to what they call "Management Situation One," a zone in which all conflicts between human use and grizzly conservation will be resolved in favor of the bear.

What you won't find in the guidelines, however, is any mention of the fact that the U.S. Forest Service is requiring the participating national forests to continue their commodity output at present levels at the same time they save the grizzly bear. Of course much of this land is already classified wilderness, but the commodity production requirements put such a strain on the remaining forest that the sustenance of wilderness resources just next door becomes harder and harder. And wilderness classification lines as they have been drawn in the Lower 48's grizzly habitat cannot possibly enclose land sufficient by itself for grizzly recovery. Yellowstone grizzlies are still redistributing themselves, largely in response to the closure of various garbage dumps where they used to feed, and they are moving farther and farther beyond the areas classified as Situation One, and what's supposed to follow now, according to the guidelines, is a redrawing of Situation One boundaries. Furthermore, the eventual range of a fully recovered Yellowstone population may very well have to include not only the habitat presently occupied but also the Gros Ventre, more of the west slope of the Tetons, more of the Absaroka north into Montana, and certainly more low-elevation spring and fall habitat all around the edges of this ecosystem. And at least until the Yellowstone population is removed from the threatened species list, all such areas, as they are recolonized by grizzlies, are supposed to be reclassified as Situation One. Now how are you going to do all that and also keep up commodity output?

And although a new coordinating body called the Interagency Grizzly Bear Committee is working hard and doing a good job, we're still a very long way from an appropriate administrative recognition of the wholeness of the Yellostone ecosystem. Two national parks, five national forests, three national forest regions, three states--and <u>one, small</u> grizzly bear population. It simply doesn't fit together.

Do these land managers <u>really</u> believe that you can continue consumptive use at high levels on a steadily shrinking land base, continue to operate without integrated ecosystem-wide management, and also reach the recovery plan's goal of 300 grizzly bears in the Yellowstone population? Somehow I doubt it. But as I say, that's what's now being tried.

The second supposition, of the value of artificial feeding, is lately much discussed by the nonprofessional public. But the Yellowstone Interagency Grizzly Bear Study Team's work has shown that there is more than ample natural food in this ecosystem for a viable population of grizzly bears. We may conclude, then, that the suppression of the reproductive rate that followed the major dump closures may have been a response to the radical change in the types and distribution of food and to the need for bears to learn or relearn different food-gathering skills. There was also a massive wave of man-caused mortality, much of it official control killing, which compounded the stress on the population. Recent indications, however, are that the distribution and food-getting skills of Yellowstone grizzlies are catching up to the new realities and are becoming much more characteristic of genuinely wild grizzly bears. They are, in short, getting enough to eat.

In any case, I think almost everybody who understands the consequences agrees now that you just can't have grizzlies feeding in garbage dumps in a national park or wilderness area. It's totally at odds with the ideal of nature preservation that is central to the national parks mission and the ideals of national forest wilderness. On the grounds that the day may come

when it is an unavoidable emergency measure, supplemental feeding of grizzlies with carrion or other foods at remote sites has been examined by a group of experts, and the logistical difficulties and the expense, they found, would be enormous. In either case--garbage dumps or feeding stations--the dangers of habituation to humans and human foods are just intolerable. I would urge those who still cling to the notion of artificial feeding to read Stephen Herrero's new book, Bear Attacks: Their Causes and Avoidance (Nick Lyons Books/Winchester Press, 1985).

It is increasingly obvious that the most immediate problem for the Yellowstone grizzly population is not a shortage of food but an excess of mortality. Richard Knight and L. L. Eberhardt's recent article in Ecology (66[2], 1985, pp. 323-334) demonstrates that "saving one adult female per year is roughly equivalent to shifting litter size from the present value to that prevailing when the garbage dumps were available as a supplementary food supply."

Long-term, the big problem is the ongoing loss and fragmentation of grizzly habitat. I suppose that if you can accept a future of continuing habitat degradation, you will have to wind up feeding grizzlies. But I can't accept it. And it is not too late to have, in perpetuity, sufficient habitat for a natural, free-ranging population of Yellowstone grizzly bears. The Yellowstone ecosystem, despite upwards of two million human visitors a year, remains remarkably healthy and productive. But for the grizzly to survive it's going to have to stay healthy and productive, and there are a lot of things going on that don't trend in that direction.

The third supposition, that this grizzly population is in deep trouble, is, unfortunately, becoming inescapable. Knight and Eberhardt's paper (cited above) describes their 5000 computer runs of a stochastic population model over a 30-year term, based on present Yellowstone population parameters. At first glance, it doesn't sound so bad: "Only about 1 of the 5000 populations was extirpated." But read on: "The results yield a mean population size of 23.3 independent females of all ages, as contrasted with 54 in the initial population." Only 36 of the initial population of females, by the way, are of reproductive age. If the same age distribution prevails after the 30 years, then only 15.5 reproducing females remain in the final mean of 23.3.

And then this: "In a 100-year run, 47% of 2000 simulation populations were extirpated." And this is under current conditions! If you look at the Forest Service's plans, you'll quickly see that current conditions seem like a dream compare to what's coming. (And some of it is coming fast. For starters, try the road-building plans on the Gallatin National Forest.)

Now, "23.3 independent females of all ages"--only 15.5 of reproductive age--just won't do it. By anybody's definition of a minimum viable grizzly bear population, that is not one.

Mortality has declined somewhat in the last few years, but probably not enough to do much good. And there is still no mechanism in place, or even contemplated, to counter the decline, beyond continuing efforts to suppress illegal man-caused mortality. But the legal mortality alone may be enough to keep the population declining. It can be argued that the standards for control killing of bears are too strict, particularly when it comes to productive females, but the political reality is that those rules are unlikely to be altered. Unnatural food sources will never be completely eliminated, and as long as that's true there will continue to be problem bears, and there is little indication that much can be done with a really dangerous problem grizzly except kill him.

Then what about replacing them? Bears can be had, from Alaska and Canada, and they don't even cost that much. What about a simple formula of one bear killed (illegally or not), one bear brought in? That way, you could afford to dispatch your incorrigible delinquents, and you wouldn't have to tie yourself in knots setting up fantastically expensive anti-mortality measures. I understand that there are technical difficulties, but if they could be worked out, in one fell swoop you could take a big whack out of the mortality problem.

The habitat problems, on the other hand, remain very difficult. And their cumulative effects are far from measurable with current means. The Yellowstone grizzly population is known to have been in decline for 20 years now, and the habitat changes now under way and foreseen in the Yellowstone ecosystem might well be sufficient to continue that decline, even if man-caused mortality could be reduced to zero. I might add that habitat degradation, fragmentation, and loss are also severe in the Lower 48's other grizzly refuges, the Cabinet-Yaak area and the Northern Continental Divide ecosystem (which includes Glacier National Park, the Bob Marshall Wilderness, and a great deal of private and multiple-use government lands). All around the fringes of these refuges, and sometimes even in their very hearts, grizzly habitat is undergoing radical change, and nobody--but nobody--is really keeping up with the cumulative impact of those changes.

The key phrase here is cumulative effects. Together with the earlier-mentioned time lag of deleterious effects on grizzly populations, the idea of cumulative effects is what makes the grizzly's situation in the Lower 48 so delicate. We have pushed and pushed and pushed multiple uses into grizzly habitat, and only some of those uses' effects are now being felt. Many more are still to come. If we want to save this animal in the refuges it now inhabits, we are going to have to cut back on consumptive uses, and it's as simple as that. We cannot continue to shave tiny slices off the grizzly's world in the belief that each one is a tolerable loss. Maybe this one really is, and that one really is too--but what about the loss of hundreds of such slices? That is the true picture of the grizzly's world today.

I want to stress the conclusion that I draw from all this reasoning: what has worked in the past will no longer work today, and what we have thought worked in the past may really not have been working at all.

There is every indication, nevertheless, that it is by no means too late. Let's think now about this idea of single species management. And let's give it a name to differentiate it from the other single species management that prevails in 99.9% of our federal lands--that is, one way or another, man-first management. Let's call our strategy, simply, grizzly first.

The remarkable thing about grizzly-first management is how good it turns out to be for just about everything else in an ecosystem. As the biologist Charles Jonkel has pointed out, grizzlies use everything from the mountaintop to the riparian zone, and when you save grizzly habitat you save the whole thing.

Grizzly bear populations can exist only in large wilderness ecosystems, and the evidence becomes clearer and clearer that these ecosystems' natural condition must remain largely undisturbed. The preservation of undisturbed grizzly habitat as a first priority in these ecosystems has innumerable benefits to us as well as to grizzlies. It means, foremost, biological wholeness. It means thriving ungulate populations to provide prey and carrion--and sportsman opportunities. It means high water quality--and good fishing. It means highly varied plant communities in all stages of succession--and ecological stability. It means a restoration of natural wildfire regimes--and thus greater safety from devastating fires. It means low-density backcountry use--and thus quiet, solitude, and serenity. It means, in a world largely characterized by agriculture, cities, and technological domination, the existence of just a few wild places that are wild in a uniquely deeply stirring way.

Such places also provide unparalleled opportunities for scientific research.

And let's not forget how few these places really are. A grand total of three ecosystems in the western United States still have viable grizzly bear populations. Three others, according to the recovery plan, are eventually to be restored. There are hundreds of wild places in the West where grizzly-first management won't be anybody's political or managerial headache, because there aren't any grizzlies there and there are likely never to be.

Moreover, many of the goals of grizzly-first management can be achieved at very low cost to the land manager. Restricting consumptive use is cheaper than promoting it. Deadfall is cheaper than harvest. Fire is cheaper than fighting fire. Not building a road is cheaper than building it. Standing aside and watching the huckleberries grow is cheaper than clearing a downhill ski run. Keeping sheep off an allotment in grizzly habitat is cheaper than paying a trained biologist as a sort of babysitter to see that the herders don't shoot grizzlies (which, by the way, as silly as it sounds, is precisely what the Targhee National Forest is doing). Enforcing strict rules on the hanging of game meat and the availability of other unnatural foods in hunting camps is cheaper than prosecuting a shoot-first-worry-later hunter for killing the grizzly that was eating his groceries or his elk.

It's just that it's so hard for Americans--especially Americans in the employ of the United States government--to understand that nothing can sometimes be the best thing you can do. Tell an American he's got a problem, and nine times out of ten he'll respond, "Well, what shall we do?" When land management agencies draw up those lists of alternatives in their planning documents, "no change" is usually included, but how often does anybody seriously consider it? Yet in the case of grizzly bears, doing nothing--nothing at all, just leave the poor buggers alone--is often in fact the preferable alternative.

It's also hard for certain Americans to imagine standing in the way of the accumulation of wealth, even when it's not their own. It astonishes me how willingly so many Americans slave away on behalf of somebody else's fat bank account. Forest Service personnel don't get rich from deficit timber sales, but a sociologist visiting from another planet would be hard pressed, I'll bet, to explain to the folks back home why some of those forest-planning earthlings in the green uniforms in Wyoming work so hard for those Weyerhauser-shareholding earthlings in the white shoes back in Connecticut.

I think that this attitude of identification with conquest is deeply rooted in our culture and our psyches. Most of the history of civilization has been devoted to overcoming natural obstacles to the growth of human population. The usual, nearly universal form of single species management--man first--is the inheritance of thousands of years of struggle.

What we have to realize now is that that struggle is pretty much over. We haven't conquered disease or death yet, but we can change the earth more or less to our liking. We have already changed most of it. And the urge to keep doing so will doubtless never be extinguished. But it is useful for us to realize how vast our powers now are, and, conversely, how powerful our occasional exceptions to that rule can be. What we preserve by letting the likes of the grizzly bear live is an image of the world of our ancestors. So what, some people demand. What's that worth?

First of all, I think the grizzly bear has a right to exist on his own, whether he's really "worth" anything at all--that is, regardless of whatever we humans may get out of it. But that is not to say that there are not deep benefits for us in letting the grizzly bear and his natural setting survive with a minimum of human manipulation or interference. Let me quote from my book, The Grizzly Bear:

"It has been in our interest as members of a technologically advancing society to forget that we are animals, not far removed from an environment much unlike the one we live in now. We are biological strangers to this life. The world which we as animals evolved for was one in which man functioned as only one of several relatively dominant animals, dependent on wild foods, subject to the vagaries of weather and natural catastrophe, fellow of the wolf and the grizzly bear: alert in ways we nearly have lost, perceiving the world more with our senses than with our minds.

"Presumably unlike the perceived world of their fellow beasts, however, that of our uncivilized ancestors was also, to a now inconceivable extent, a spirit-world. Where their senses left off, their human imagination took over. Darkness was full of brooding menace, silence alive with numinous voices, a starry sky the realm of divinity. It was a world they could not dream of mastering as we have mastered ours, and that humility bred awe, an awe which our own not unjustified civilized pride has obscured.

"But not quite extinguished. It is not just as make-believe primitive man and fellow beast that we come into the wilderness, but also in quest of that lost sacred awe. We come as a king might come disguised among his peasantry, trying to feel unalient in a world that seems more real than our daily busy noisy own--which, in terms of biological familiarity, the wilderness truly is. False though our atavistic incursion into an image of the distant racial past may feel, we also feel our pulse really slow down, the muscles in our social face really relax. We hear the rustlings and stirrings of the living creatures around us.... We peer into the darkness, and wonder. We listen into the silence for voices too still and small to be heard within ourselves in the deafening life we usually lead. In half-pretended faith, we feel our way back toward a love of nature not unmingled with dread; we are at once alone and at one with all; and an ancient awe steals over us."

This is something, I think, that you can't quite measure. But when you manage wilderness for grizzly bears, it is undeniably then an available "resource."

What it costs to preserve the grizzly bear and a wild world sufficient to support him is probably quite measurable, in dollars and convenience and social welfare. What must be sacrificed in board feet and so in the cost of new buildings? What increase will there be in the price of oil and natural gas if we forego the deposits that lie beneath the grizzly's kingdom? What would the setting-aside intact of grizzly bear habitat do to the cost of beef and lamb and wool and silver and copper and real estate and elk-hunting trips and downhill skiing? What will be the national cost of this national treasure?

Not very damned much, that's what.

And what will be gained? I wish I could describe it in terms of greater justice than "ancient awe" and "national treasure" and "an image of the world of our ancestors," because there's so much more to it than that. I think most of us can feel it, but it seems to exist in a region of the mind beyond words. I can only name part of it, which stands, nobly, for it all, and in some deep way, I think, for us all. The grizzly bear.

BALANCED MANAGEMENT OF THE GRIZZLY

Roberta Andersen

ABSTRACT: Semantics play a major role in arguments among preservationists, multiple-use advocates, and others over protecting grizzlies and providing development opportunities. Many bandwagons are going in different directions. Public opinion on the issues is predictable, and not very helpful in solving the problems. Needed is a national commitment to a reasonable level of grizzly recovery, tough decision making to define it and bring it about, recognition that society needs both production and preservation, and development of tolerance for each other's needs for resource use.

INTRODUCTION

When Dr. Streeter called to ask me to fill in for Senator McClure on this panel, I could only hope word of it wouldn't leak, because I know the Senator would be singularly underwhelmed by the fact.

Likewise, when I received his letter listing the other members of the panel, I couldn't help wondering who they were subbing for...

And when I read an article that said Chris Servheen is "the ranking grizzly professional among public servants in the country," I began to think of ways to call in sick.

But the temptation to be here was just too great. The problem is just too interesting; its possibilities too bold; its drama too intense.

I've been involved in various public land controversies for a long time, so I know a little bit about this debate. But the bulk of the "lower 48" grizzly bear habitat has pretty much been in National Parks and Wilderness, both of which, as you know, are statutorily precluded from access for energy exploration. If access is not denied by statute, as in a so-called multiple-use area, the rhetoric is so strident and the headline type so bold (if Grizz are even <u>thought</u> to use the area) that access wouldn't <u>just</u> take a month of Sundays to accomplish--it would take years and years of Sundays. Also, the ladies and gentlemen of the surface managing agencies would write so many environmental impact statements about the "possible, horrible, cumulative devastation and destruction that would doubtless occur" should we discover oil, that our geoscientists would have to have an improbable degree of certainty that it's also oil and gas habitat before we would even try for access.

So I continued my research for the panel with the idea that, as a very interested citizen, I'd be the outside eyes and ears for this distinguished team of experts.

A SEMANTIC ARGUMENT

I'm a wordsmith, a student of human behavior, and not a grizzly bear scientist. I know that any argument carried far enough will end up in semantics. Listening to my fellow panelists and watching your reactions, I believe that's what has happened to this debate.

For purist preservationists, the current trendy semantics call for establishment of "ecological boundaries," with all life forms within those boundaries naturally perpetuating the ecosystem. All life forms except man, that is. For others in the multiple-use community, the very idea of such a thing makes them crazy. There are all shades of concern: outfitters won't be able to guide pack trips except under severe limitations and regulations; ranchers won't get to use their domestic livestock grazing allotments; Federal managers will lose turf; and recreationists will either be closed out altogether, or will be so severely regulated that they'll end up saying, "Why go there anyway? That's Grizz country."

When Yellowstone National Park was dedicated in 1872, those who did so called it "a Public Park and pleasuring ground for the benefit and enjoyment of the people." Did they anticipate that one day Parks would not be for people anymore?

This problem of grizzly bear semantics strikes me as being the ultimate proof of Halls Law: "The means justify the means. The approach to a problem is more important than its solution." Or is it Smith's Law: "No <u>real</u> problem has a solution." (Many of the quotes herein were taken from <u>Murphy's Law</u> Volumes 1, 2, and 3).

It certainly proves beyond the shadow of a doubt the bureaucracy principle: "Only a bureaucracy can fight a bureaucracy."

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With the Craighead corollary, of course: "Never get caught between two bureaucracies."

Several things have struck me as irrefutable, as I have listened to and watched the presentations today:

1. Two monologues do not make a dialogue;

2. When working toward the solution of a problem, it always helps if you know the answer; and

3. Under the most rigorously controlled conditions of pressure, temperature, volume, humidity, and other variables, the organism (the bear) will do as it damn well pleases!

In 1967, the National Academy of Sciences and the U.S. Fish and Wildlife Service said populations of bears in Yellowstone were viable and self-sustaining. In 1975, grizzlies were declared "threatened" in the lower 48 by that same Fish and Wildlife Service. Since 1975, the decline has reportedly accelerated in Yellowstone, and the only major management change was closure of the garbage dumps in the Park.

One side therefore says, "Go back to feeding the bears," while the other says, "No, they must survive in a natural setting by natural means or go their way with dignity." One side says, "Close off the whole 6-million-acre ecosystem to everything but nature's forces," while the other says, "It makes much more sense to manage today's world than to try to return to the over-glorified days of yesteryear."

WHICH BANDWAGON?

Now, jumping on the bandwagon is O.K. so long as the bandwagon is going the right way. But which bandwagon is?

One side says, "Where there's sport hunting, bears develop fear of man; where there's none, bears lose their fear of man." The other side says, "The species is declared 'threatened' under the Endangered Species Act; you can't be killing them for sport in Montana!" The hunter in the middle says, "Statistics prove being shot is one of the most stressful experiences in Beardom."

Some say, "We know how many bears there are: we've counted the females, multiplied by the cubs, and divided by the males, and that's how many bears there are." Others say, "You cannot possibly know how many bears there are unless you individually tag or collar every one." Some say, "Collaring won't hurt the bears, and it will help our research.". Others say, "If you put collars on those bears, you'll kill 'em, 'cause they'll be so stressed, they won't reproduce at all. They'll be dead, Charlie, just as sure as if you shot 'em."

And members of Congress say, "Oh my Gawd," because they know if they don't support the bears, they'll be defeated at the polls; and if they do support the bears, they'll be defeated at the polls.

We have absolutely proven with all the charges and counter-charges thrown around this arena that it doesn't matter how long it takes you to get there if you don't know where you're going. We have seen absolutely that the length of a progress report is inversely proportional to the amount of actual progress. We have reams of research, now called applied research because it relates to things which are purported to be problems, but about which everyone claims to have inadequate data to determine that they are, in fact, problems.

Bears still haven't learned to read maps, and still don't know how many exciting boundaries have been drawn, and laws passed, in their behalf. Bears just do what bears do.

I know that by now, you're feeling just a little bit insulted; you are accusing me of making light of a very serious situation. But, again, I'm looking at this problem from the point of view of an interested, educated citizen who cares about bears, and I must say to you, "Why don't you just quit your squabbling and get on with solving the problem?"

PREDICTABLE PUBLIC OPINION

When you ask people in a public opinion poll if they favor keeping or losing the bears, I guarantee they'll choose keeping them. When you ask how many we should keep in the Yellowstone Area, they'll say, "I don't know, but somebody should." When you ask them if they would rather have dirty air and water or clean air and water, they'll opt for clean every time. When you ask them if bears should be hunted, the hunters will say, "sure," and the nonhunters will say, "No way!" I can guarantee these results in your opinion poll.

So it seems that we are going to have to choose somebody to make those nonfabled "tough decisions," and do it quickly. It shouldn't be a purist preservationist, an ardent developer, an agency manager, or a grizzly bear biologist. All those people are just too close to the situation, and too polarized in favor of their idea being the only solution.

Nobody can decide the size of an area needed for recovery of the species until we have defined "recovery." When do we know we have enough grizzly bears? If this is really about grizzly Recovery (with a capital R), and not just another scheme to withdraw public land from possible use and development, then we have to swallow our pride, admit that everyone has a scheme that won't work but parts of all of them may. We have to take that first step toward long-term grizzly population stability. It's going to take a decision maker who will use knowledge and education, available information, common sense,

and personal confidence to say, "This is what we must do to manage for Recovery."

If everything we try doesn't turn out to be a smashing success, we can always use it as an example of what not do do. We have a lot of these already. If something works, we can say the bear has benefitted.

WE CAN'T GO BACK

But we can't go back; we can't re-create any ecosystem to its prewhite man natural state. Man was here; man is here; man can and should use his intelligence to benefit other life forms where it is appropriate.

Let's say Recovery in Yellowstone equals 300 grizzlies. We'll need some vegetation manipulation; we may need some extra food for the bears from time to time; we'll probably need a whole lot of education for our citizens as to the realities of bear management; we must lose a good deal of bear mystique, and come up with some realistic assessments of what bears do and what man must do to benefit Recovery. We will develop so we'll have a domestic resource product base to be able to protect the bear at all. We may have to expand habitat in some places, and we'll have to correspondingly reduce it in others. We frankly don't need to add much more to the research data base right now. What we need are a national commitment to 300-bear Recovery and a tough cookie to call the shots. Then, when we have achieved Recovery, because we can and will, we must give appropriate credit, move on to maintenance, and not change the rules of the game to--now we must have 400 bears. For that, without doubt, is what keeps happening to the environmental game, which has destroyed much of its credibility. It's been skillfully turned from science to politics. It used to be a crusade; now it's a racket.

We are not an either/or society. We must have both production and preservation! We must have both grizzly bears and mankind. Everything we have, eat, wear, live in, drive, and do comes from the earth; and surely something that must sustain us also deserves our respect. (You'll also get that answer in your opinion poll, by the way.) But we cannot draw phoney political lines and expect to come up winners. We have to live together, tolerate each other, and acknowledge each other's use of the land. We need to train ourselves and our children to obey natural laws, to clean up, to conserve, to pack out what we pack in, and to foster appreciation among all people for the truth of what we have. Until we do that, it doesn't matter what we do about the bears; they don't care anyway; they're just doin' their bear thing.

THE RELATIONSHIP BETWEEN THE PRESERVATION OF WILDERNESS VALUES AND ENDANGERED SPECIES: A CASE-STUDY FROM THE UPPER COLORADO RIVER BASIN, U.S.A.

Charles M. Haynes and James R. Bennett

ABSTRACT: The endangered Colorado squawfish (Ptychocheilus lucius) is endemic to the Colorado River system of North America. Its status is a consequence of largescale habitat alterations resulting from western U.S. water development practices and, at present, it is limited largely to portions of the upper basin in the States of Colorado and Utah. In Colorado, an important spawning area has been identified in the lowermost 20 mi of the Yampa River (Dinosaur National Monument). This area has retained much of its "wilderness" character and may serve as an excellent example of the value of maintaining unaltered ecosystems for the recovery and management of endangered species.

INTRODUCTION

Proponents of wilderness preservation have alluded to the value of unaltered natural areas for the maintenance of rare and dwindling genetic resources. Indeed, one of the most essential needs in the field of conservation ecology is knowledge of the minimum habitat size necessary for long-term maintenance of selected species or groups of species (Lovejoy 1979). Given the critical nature of tropical ecosystems to the earth's climate and the impressive diversity of plant and animal life associated with these ecosystems, it is not surprising that, in the face of an accelerated rate of deforestation worldwide, much effort and publicity is given to research and management efforts in the American tropics and elsewhere. Similarly, the situation with the rare and endemic fishes of xeric portions of western North America is fairly well known by professional ecologists though perhaps less widely publicized and understood by the interested public. In the Colorado River basin, for instance, water development beginning in the late 19th century and proceeding to the present has produced one of the most severely altered regional ecosystems known, and concomitantly, imperiled several species of its unique native ichthyofauna (Holden 1979).

The purpose of this paper is to describe the current situation affecting the future of a particular Colorado River endemic, the endangered Colorado squawfish (Ptychocheilus lucius)--(1) its distribution and status, (2) current recovery-oriented research, (3) the relationship of its long-term survival to the ecological characteristics of a specific de facto wilderness system[1], the lower Yampa River (Dinosaur National Monument, Moffat County, Colorado), and (4) suggested approaches to future research/management necessary to assure its recovery and perpetuation.

HISTORY, DISTRIBUTION, AND STATUS OF THE COLORADO SQUAWFISH

The Colorado squawfish (fig. 1), a large predatory cyprinid, is congeneric with three other squawfish species endemic to west coast (North America) drainages. Tyus (1984a) has summarized knowledge relating to known archeological finds of the genus. Fossil Ptychocheilus similar to modern P. lucius have been reported from a number of Pliocene sites in the southwest and apparently utilized both riverine and lacustrine habitats. Miller (1961) contended that, based upon a comparison of Pliocene and modern fossils, an adaptation to swift-water habitats had occurred by mid-Pliocene. Modern species of Ptychocheilus are relatively large fishes, and the Colorado squawfish has evolved into the largest native cyprinid in North America with purported lengths in excess of 5 ft and weights of 80-100 lbs (Miller 1961). The largest squawfish documented in the State of Colorado, however, was approximately 3 ft in total length and about 18 lbs (Wick and others 1981). Tyus (1984a) has suggested that attaining such a large size in modern

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[1] Cross Mountain, a 17,500-acre area bordering the Yampa River approximately 10 mi east of the Dinosaur National Monument (DNM) boundary has been included as a Wilderness Study Area by the Bureau of Land Management as has an additional 22,600-acre area adjacent to the northern boundary of DNM (United States Bureau of Land Management 1980). The 47-mi reach of the Yampa River from the eastern boundary of DNM to the confluence of the Green River has been designated as eligible for inclusion in the National Wild and Scenic Rivers System (National Park Service 1979).

Figure 1.--Mature Colorado Squawfish captured in the mainstem Colorado River, Moffat County, Colorado. Specimen was approximately 3 ft (total length) and 18 lb.

P. lucius would be an adaptive evolutionary response to a widely fluctuating riverine environment which might select for a species that would grow larger and live longer to produce a large number of offspring during desirable wet years. Such a strategy would confer more positive adaptations than one of smaller size and early reproduction, particularly in a large-river ecosystem such as the Colorado drainage.

Historically, Colorado squawfish were distributed throughout the Colorado River drainage from the Green River in Wyoming to the Gulf of California (Sea of Cortez). The species apparently began to suffer declines in the mid-1930's where, heretofore, it had been abundant enough to support local indigenous and commercial fisheries (Minckley 1973). P. lucius, an obligate riverine species, was apparently unable to adapt to the massive habitat alteration that accompanied the construction of several mainstem dams in the lower basin, beginning with the completion of Hoover Dam in 1935 and was functionally extirpated from the lower Colorado River mainstem and its Gila and Salt River tributaries by the early to mid-1960's (Holden 1979). It now persists largely in relatively undeveloped areas of the upper Colorado River basin above Lee's Ferry, Arizona, and it is presently listed as "endangered" by the United States Department of the Interior throughout its historic range and by the State of Colorado.

As is the case with so many "nonresource" species (adopting the relevant terminology of Ehrenfeld 1976), little specific life-history or population information was known prior to the initiation of the studies which are the subject of this paper. Squawfish are the top native carnivore in the Colorado River system (they now receive competition from a number of introduced exotic predators) and are believed to be exclusively pisciverous above approximately 8 in. in length (Vanicek and Kramer 1969). Studies by Vanicek and Kramer (1969), Holden (1973), and Seethaler (1978), among the more notable, documented that mature Colorado squawfish were widespread but nowhere abundant in the Green and Yampa River system of northeast Utah and adjacent northwest Colorado and were typically associated with deep pools and a variety of substrates. Juveniles were captured in shallow shoreline embayments over silt substrate. Reproduction, based upon the capture of ripe adults was assumed to coincide with decreasing flows and rising summer water temperatures that are characteristic of snowmelt-driven southwestern rivers.

Unquestionably, these researchers were observing the long-term impacts of one of the gravest misjudgments ever made in recent western fisheries management, i.e., the Green River rotenone program carried out in 1962 in conjunction with the closure of Flaming Gorge Dam in northeastern Utah. Large numbers of Colorado squawfish, in addition to several other native species, were eliminated from over 250 mi of the mainstem Green River to create a non self-sustaining salmonid fishery (Minckley and Deacon 1968). A similar program was conducted on the San Juan River with the closure of Navajo Dam in New Mexico. Although the long-term meaningfulness of such poisoning losses is arguable, the loss of habitat to cold reservoir tailwaters and long lacustrine reservoir reaches unquestionably contributed to the continued decline of the Colorado squawfish in the upper basin (Colorado River Fishes Recovery Team 1978).

In addition to the unfavorable riverine and reservoir habitats created during the 1960's period of dam building in the upper basin, the dams themselves served as enormous barriers to a species that, due to its reported migration habits, was sometimes referred to as the "white salmon of the Colorado" (Holden 1979; Tyus 1984b). At the same time, flows of the upper basin have been continuously diverted to eastern Colorado by more than 40 transmountain diversions and substantial quantities of water have been lost to evaporation in reservoirs and via irrigation. Such regulatory and consumptive practices have resulted in an upper basin ecosystem that is altered both in terms of water quantity and out of phase relative to historical seasonal cycles (Bishop and Porcella 1976). Clearly, the Colorado squawfish is faced with an ecosystem that is at variance in several major respects from that in which it evolved and at present, the species appears to be restricted to about 25% of its former range (fig. 2)(Tyus 1984b).

LOWER YAMPA RIVER RESEARCH: 1980-PRESENT

It is relevant to have an understanding of the state of knowledge relative of the ecology of the Colorado squawfish in the upper basin prior to the initiation of lower Yampa River studies in 1980. The distribution of the species in the upper basin was fairly well understood as a result of studies in the mid-1960's through the late 1970's by Banks (1964), Vanicek (1967),

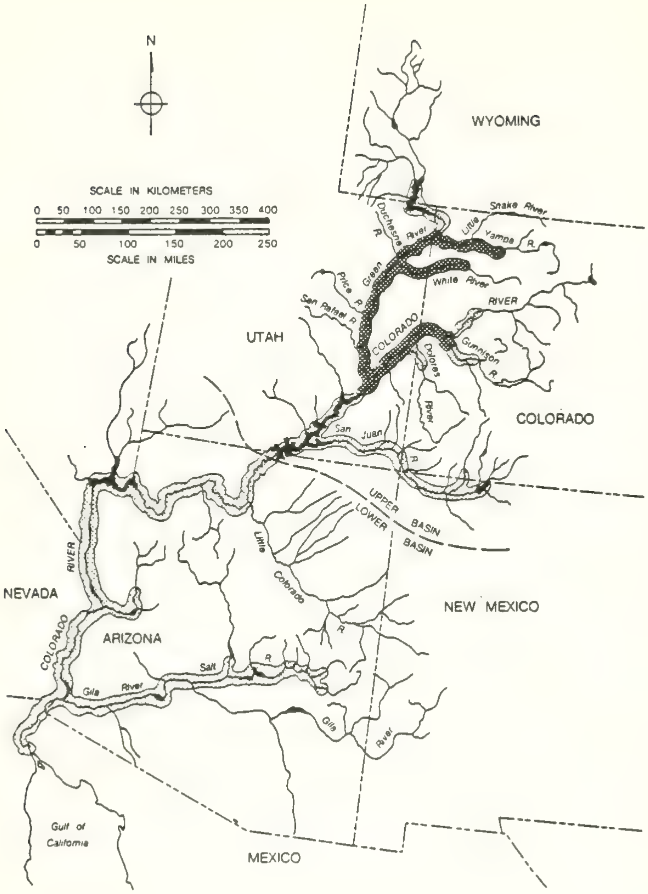

Figure 2.--Historic (light stipple) and existing (dark stipple) range of the Colorado squawfish in North America.

Holden (1973), Seethaler (1978) and others. Squawfish were distributed erratically throughout the basin, including the mid-lower reaches of the mainstem in Utah and Colorado, and its principal tributaries, the White, Gunnison, Green and Yampa Rivers. The species' range as detailed by the above investigators was, with some resolution, fundamentally correct as revealed by subsequent field studies initiated by the Colorado Division of Wildlife (DOW) in 1977 and the Colorado River Fisheries Project (CRFP) of the U.S. Fish and Wildlife Service in 1979. Critical life history data were limited to observations of habitats occupied by adults and timing of sexual maturity. Absolutely no observations of natural spawning had been documented.

The early life history stages of P. lucius were known as a result of hatchery propagation at Willow Beach National Fish Hatchery, Arizona, by Toney (1974) and Hamman (1981) and larvae/juveniles were available to researchers for comparison with field specimens.

The consensus of opinion prior to DOW/CRFP studies was that if the Colorado squawfish spawned at all in Colorado, it would be in the lower mainstem. The Yampa River was believed to be very near the edge of the species' range and far too small to support spawning for such a large fish.

THE LOWER YAMPA RIVER ECOSYSTEM

The Yampa River (fig. 2) is the principal tributary of the Green River sub-basin. It heads in the Park and Gore ranges and the Flattop Mountains in northcentral Colorado and flows north to Steamboat Springs (Routt County) where it turns west to the Green River confluence in Dinosaur National Monument (Moffat County). The river is approximately 200 mi in length, and the last 47 mi are wholly within the boundaries of the national monument. The Yampa exhibits wide annual fluctuations in physicochemical characteristics, due largely to its snowpack dependence and the semi-arid nature of the watershed over a great part of its course. Flows can range from $<$100 ft^3/sec during the base flow period of September-February to $>$20,000 ft^3/sec during the last week of May when peak flows are typically recorded. Water temperatures similarly fluctuate widely, i.e., from 1.0 C (winter) to approximately 30 C (July and August). Turbidity (napthalmic turbidity units) ranges from $<$1.0 during fall-winter base flows to $>$100 during peak runoff and following prolonged storms (USGS 1983; O'Brien 1984). Color is brown to brick-red during runoff and often through August. The Yampa River in Dinosaur National Monument has a mean annual flow of approximately 50 billion ft^3 (National Park Service 1979) and it is the last large free-flowing river on Colorado's western slope. In contrast with the mainstem Colorado River and its other principal tributaries, present Yampa flows appear to approximate historical discharge patterns with normal seasonal fluctuations.

The lowermost 46 mi of the Yampa River are entirely contained within deep canyons (Yampa Canyon). Because of the Canyon's geology, the river may be subdivided into an upper, high-gradient reach (river mi 46-20) characterized by a boulder-cobble substrate and a lower, low-gradient reach (RM 20-0) where sands and silts increasingly replace the large boulders. Riverine habitat varies from major/minor rapids and eddies, particularly in the upper reach, to relatively deep, quiet pools and braided sections interspersed with cobble bars in the lower reach (O'Brien 1984).

As is the case with essentially all reaches of the Colorado River system, several species of exotic fishes have become established in the Yampa River (Haynes and Muth 1984) and introduced tamerisk (Tamarix gallica) is becoming established on the beaches. However, unlike the dam-controlled Green River with which it joins, relatively natural seasonal Yampa flows have maintained a largely native riparian ecosystem with deposition of driftwood and local cottonwood (Populus fremonti) germination during wet years.

Field studies in Yampa Canyon are logistically difficult, requiring travel by inflatable raft and canoes and fish sampling is inefficient, at best. Studies, with the expressed intent of determining the likelihood of squawfish spawning in the lower Yampa River, were initiated in

August, 1980 by DOW and followed by CRFP in 1981. Field work has continued to present. DOW efforts were oriented largely toward the collection of early life history information as was done in 1979-80 on the mainstem Colorado River (Mesa County). CRFP efforts were an extension on upper Green River (Utah) studies and were initiated following the collection of squawfish larvae by DOW researchers during the initial 1980 trip. CRFP studies were designed to evaluate adult movements within the Yampa River and between the Green and Yampa Rivers via radiotelemetry and to identify spawning sites. CRFP field methods have been described by Archer and others (1980) and Tyus and McAda (1984) and need not be reiterated here. Similarly, DOW methods have been previously described by Haynes and Muth (1983, 1984), Wick and others (1981, 1983), and Haynes and others (1984).

Figure 3.--Early May, 1983, view of spawning area at river mile 16.4, Yampa Canyon, Dinosaur National Monument. The cobble bar is approximately 900 ft long and 300 ft wide.

RADIOTELEMETRY FINDINGS

Spawning migrations had long been hypothesized for the Colorado squawfish but never documented. Long distance movements between Utah's Green and White River had been observed by CRFP (Tyus and others 1981) in 1980, but the relationship of this movement to spawning was unclear. In the spring of 1981, radio transmitters were implanted in mature squawfish in the upper Yampa River (above Dinosaur National Monument) and in the Green River in Utah. Continuous tracking revealed that seven of the implanted Yampa River fish moved downstream 50 to 100 mi. to the lower Yampa and that one Green River fish moved approximately 96 mi upstream to approximately the same site. Radio-tagged fish remained in the lower Yampa from late June to early July and subsequently returned to their premigratory locations. At the same time, squawfish to which small plastic tags had been attached as early as 1978 elsewhere were found in association with radio-tagged individuals in the lower Yampa (Tyus and McAda 1984). Observations were continued in 1982 by Wick and others (1983) working under the authority of the National Park Service and DOW with similar results except that transmitter implants were restricted to Yampa River fish. Results were confirmed with continued studies by Tyus in 1983. In all years, ripe squawfish appeared to congregate on cobble bars 20 mi above the Green River confluence (fig. 3). Trammel net collections made near these bars when radio-implanted fish were present revealed a large number of ripe fish. As was the case in 1981, radio-tagged squawfish in 1983 returned to premigratory locations following their presumed spawning (Tyus 1985).

Long distance potamodromous migrations are unusual in N. A. freshwater fishes, and observations by the above researchers yielded several notable facts. Many of the observed movements covered substantial distances and involved as many as three rivers. For example, Wick and others (1983) captured a fish at a cobble bar (RM 16.4) which had been tagged with a small plastic Carlin smolt tag in Colorado's White River the previous year over 250 mi away. This individual migrated from the White River in Colorado to the Green River in Utah upriver to the Yampa, again entering Colorado. Migrations occurred within one drainage basin in both upstream and downstream directions. Movement appears to begin during spring runoff with water temperatures as low as 16 C and convergence at spawning areas occurs during the descending limb of the hydrograph at temperatures of 18-22 C. Fidelity to a single site in the lower Yampa River is notable. Although ripe fish were captured by the above researchers at several lower Yampa locations, the majority of ripe fish congregated eventually at cobble bars at RM 16-20. Tyus (1985) has hypothesized that limestone seeps at this and another site subsequently discovered in the lower Green River in Gray Canyon, Utah (this second site appears to support a second unrelated spawning migration),constitute an olfactory basis for homing in Colorado squawfish comparable with that long known for salmonids.

EARLY LIFE HISTORY STUDIES

Forty-six larval squawfish were captured in the lowermost 9 mi of Yampa Canyon in 1980 and 23 the following year (table 1)(Haynes and others 1984). Larvae were collected over a wider area in the second year and extended to RM 18. Over 200 individual fine-mesh seine (1/16- and 1/32-in. square mesh) and dip net (1/32-in. square mesh) samples were required to collect 1981 specimens, but more than 500 discrete samples collected during the spring-late summer were required to collect half as many larvae the following year. Studies were continued in 1982 and only 20 larval squawfish were collected from 300 samples. In all cases, larvae were restricted to shallow shoreline embayments and backwaters, frequently isolated from the main channel by rapidly falling water levels.

Table 1.--Larval Colorado squawfish collections, Yampa Canyon, 1980-83. 1980 values include collections made with dip nets; 1981-83 collections were made exclusively with seines

Year	[a]No. of samples	[b]Dates	[c]Localities (mi)	N	[d]C/E	TL range (in.)	Est. spawning period (dates)
1980	215(9)	23-25 Aug	0.1-8.6	46	--	0.55-1.14	2 July-8 Aug
1981	519(11)	24 July-15 Aug	0.1-17.9	23	0.79	0.35-0.87	6-30 July
1982	310(10)	7-25 Aug	0.3-12.2	20	0.18	0.39-0.83	24 July-8 Aug
1983	245(17)	22 July-21 Aug	0.7-12.3	228	5.59	0.34-0.66	24 July-11 Aug

[a]Numbers in parentheses represent numbers of collections which contained one or more larvae.
[b]Dates of earliest and latest larvae collection.
[c]Distance from mouth of Yampa River (mi 0).
[d]Number larvae/1000 ft^2 specific habitat.

In 1983, the use of fine mesh (560 micron) plankton nets was included in the sampling design to evaluate the possiblity of downstream drift following hatching. Three nets were deployed along the shoreline at each of two sites. One site, at approximately RM 20.5, was selected to determine if spawning occured above the previously documented RM 16-20 reach. The downstream site was approximately 2 mi above the river's mouth and was selected to follow any drifting larvae into the Green River. Sampling was initiated at water temperatures of approximately 18 C in early June and continued through late August when flows were too low to permit travel. Collections were timed to evaluate the possibility of diel activity patterns. Seine sampling was continued and restricted to the lowermost 22 mi of Yampa Canyon. An additional unanticipated factor in 1983 was an unusually high flow regime with flows of approximately 22,000 ft^3/sec in late May.

A total of 331 larval Colorado squawfish were collected in 1983, 228 of which were collected by seine from shallow shoreline embayments. Of the drift specimens, only one was collected at the upstream site, strongly suggesting that spawning was indeed limited largely to the lowermost 20 mi of the Canyon. Diel periodicity of squawfish could not be demonstrated statistically. Interestingly, native fishes (predominantly larvae and juveniles) were far more abundant in the drift and compromised 83% of the total catch. Only channel catfish (Ictalurus punctatus), an introduced riverine species, were collected in numbers comparable with the most abundant native species. In 1980-82, squawfish numbers were too small to make realistic evaluations relative to spawning "intensity;" however, back-calculated spawning dates for 1983 revealed that while limited spawning occurred as early as 11 July (mean water temperatures=18-20 C), a peak in spawning activity occurred between 25 July and 10 August (mean water temperatures=22-25 C). This peak in spawning activity coincided closely with dates when radio-tagged fish were active over the spawning area (H. Tyus, CRFP, pers. comm.). Spawning after 10 August was sparse and appeared to cease by 20 August (mean water temperature = 29 C).

Capture/effort (C/E) calculations made exclusively on seine collections for the years 1981-83 (1980 data were excluded since a number of different methods had been used to collect larvae) suggested that a 1983 value of 5.59/100 ft^2, 7-20 times greater than the two previous years, was indicative of greater larval production during the 1983 high-flow year than during the two previous years when flows had been substantially lower. Interestingly, although the mainstem Colorado River similarly experienced a very high flow regime in 1983, C/E in that year was lower than in 1982. When thermal regimes (in terms of summed 22 C+ degree-days) were compared, heat accumulation in the Yampa River in 1983 was comparable with 1982 when flows were considerably lower. On the Colorado River, 22 C+ degree-day accumulation in 1983 was substantially less than in the previous 2 years and only 65% that of the Yampa in 1983 (Haynes and Muth 1984).

The combined seine-drift sampling design was repeated in 1984. Laboratory processing and data analysis are in progress and therefore not included in this synthesis.

Tyus (pers. comm.) has reported the collection of larval and juvenile squawfish from Green River backwaters (Utah) and it is presumed that these individuals originated in the lower Yampa since no other upstream spawning aggregations have been documented. Only a single squawfish juvenile has been collected in Yampa Canyon since initiation of studies. Thus, larvae originating in the Yampa appear to be transported downstream via drift to nursery sites in the Green River.

SYNTHESIS: MANAGEMENT IMPLICATIONS

The Colorado squawfish is a top-level carnivore which requires a diversity of habitat variables and a large range to fulfill its life requisites. While feeding and overwintering may be accomplished in several areas, reproduction appears to require specific conditions that are available in only a few selected reaches. Migrations in the upper Green and Yampa Rivers coincide with warming conditions during spring runoff and spawning appears limited to a relatively short reach of the lower Yampa River in Dinosaur National Monument. Peak spawning activity apparently occurs at water temperatures of approximately 22-25 C, although limited spawning occurs both above and below this range. Following spawning in the Yampa, primarily at RM 16-20, adults appear to return to their premigratory locations, often >100 mi away--some moving upstream, others moving downstream. Eggs hatch in 3.75-6.0 days (Hamman 1981) and protolarvae of 0.24-0.29 in. (total length) spend 22-96 hrs in the cobble prior to swim-up, at which time they may be swept into the currents to be transported down the Yampa River. An unknown proportion of squawfish larvae deposited in quiet shoreline embayments by countercurrents are subjected to predation, competition, heating, desiccation, and in winter, freezing. Hypothetically, it is to the advantage of squawfish larvae to be rapidly transported out of Yampa Canyon to more permanent, structurally diverse backwaters in Utah's upper Green River (Haynes and Muth, in prep.).

Based upon complementary CRFP-DOW studies, larval production in the lower Yampa River may indeed drive the entire upper Green River system above Gray Canyon, Utah. A second spawning site in the lower Green River appears to support an independent spawning sub-population (fig. 4). Similar studies on the mainstem Colorado River have not yielded similar results, although larvae have been collected (Haynes and others 1984; Haynes and Muth 1985), and adult migrations do not appear to be as pronounced there. It is possible that the perturbed mainstem and its other tributaries no longer offer the necessary combination of habitat variables found in the relatively unaltered lower Yampa. This is clearly a case for continued radiotelemetry studies.

Unquestionably, the relatively unaltered lower Yampa River in Dinosaur National Monument still retains the natural features essential to Colorado squawfish production for a major portion of the upper Colorado River basin and the protection of this vital area appears critical to the long-term survival of the endangered Colorado squawfish. Any river development above or below this short reach must consider the maintenance of migrational corridors, sufficient spring flows to flush spawning areas of sands and silts accumulated during previous base flow periods, and the water temperatures which are conducive to spawning, egg maturation and hatching. Furthermore, because spawners originate both upstream and downstream from the area, migrational routes must be maintained in both directions; otherwise

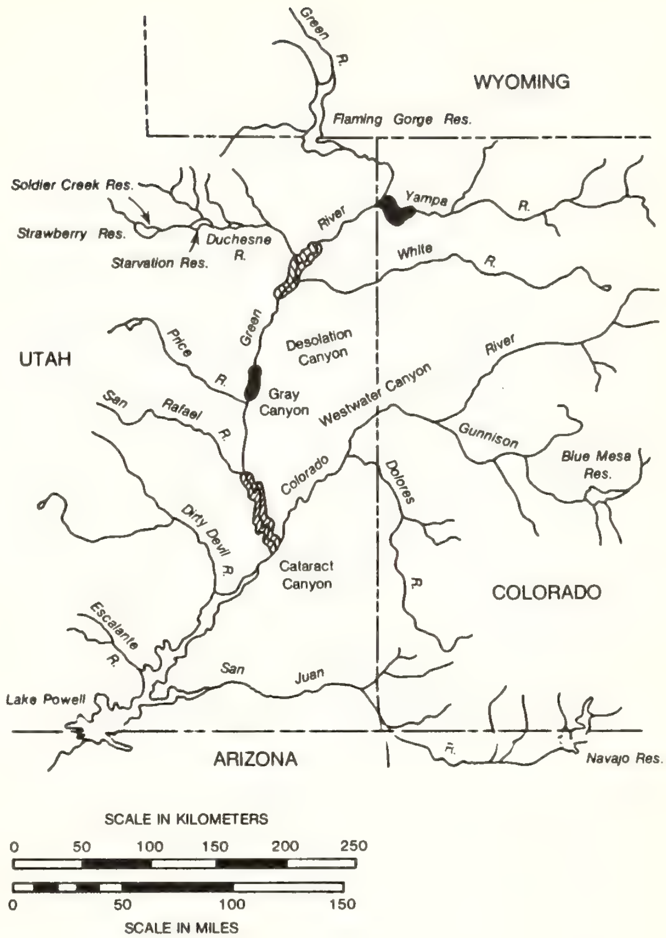

Figure 4.--Confirmed spawning (black) and nursery (shaded) locations for the Colorado squawfish in the upper Colorado River basin. As is the case for lower Yampa Canyon, the Gray Canyon spawning area retains much of its wilderness character (after Tyus 1984b).

spawning could be limited to individuals from a single area, thereby adversely affecting the future genetic vitality of the species.

A major bottleneck to the well-being of the upper Green River squawfish may exist at the mouth of the Yampa River. At the confluence with the dam-regulated Green River, drifting squawfish larvae are confronted with water temperatures that can, for short periods, be as much as 10 C colder than the natal Yampa. The potential impact on minute squawfish protolarvae requires evaluation. Further, during the wet year of 1983 when larval production appeared relatively high, observations at upper Green River nursery areas in Utah suggest that larvae perhaps did not reach these areas in numbers as high as in 1981-82 (H. Tyus, pers. comm.). If this perceived high mortality of the 1983 year-class is ultimately linked to reduced water temperatures in the Green during downstream transport or to some other combination of factors resulting from high releases from Flaming Gorge Dam, the management plan for the reservoir should be modified to reduce or eliminate these impacts.

Research, to date, has revealed a number of basic aspects of the life history and limiting factors for the Colorado squawfish. Unfortunately, much vital knowledge relating to the biology of this unique fish is incompletely understood and will be essential to the future management and recovery of the species. A number of deficient areas await resolution. The following list of questions suggests future research objectives. The list is not intended to be exhaustive nor are topics ranked according to priorities.

1. How will we recognize when the Colorado squawfish is "recovered"? If recovery is to be defined in terms of a specified number of self-sustaining subpopulations, we must develop methods which allow us to recognize "self-sustaining". Is it necessary that the species be self-sustaining every year throughout its range for recovery to be achieved?

2. How can we recognize when "good" or "bad" things are happening to the species? Relative abundance indices (e.g., C/E) are promising but require close scrutiny relative to sources and magnitudes of error. It must be recognized that C/E methodologies do not lend themselves well to application in an open system like the Colorado River and their results can be misleading.

3. Is there a measurable relationship between flows (assuming comparable thermal regimes) and larval production on the spawning grounds? Hypothetically, high flows such as those observed in 1983 fit well into Tyus's (1985) hypothesis of evolutionary adaptation for wet years. High flows could serve to flush spawning bars and, if flows do not recede too rapidly, provide greater substrate area for spawning.

4. Do high spring flows suppress spawning of exotic species while enhancing squawfish spawning? Evidence from the Yampa in 1983 suggests that this may be the case, however, observations from the mainstem Colorado suggest that exotic species may actively avoid currents and not be caught by drift sampling techniques (R. Valdez, pers. comm.). Should future studies demonstrate that exotic species are in fact suppressed by high spring flows, this knowledge could conceivably be incorporated into a basin-wide water budget.

5. How do we monitor (census) the species in the upper basin? At what life stage? Can carefully timed drift collections be used as economically efficient monitors of larval production?

6. Are squawfish larvae truly aperiodic? Evidence from the Soviet Union suggests that cyprinids may exhibit diurnal periodicity in clear rivers but that the same species may drift around the clock in rivers of low transparency (Pavlov and others 1977). If this is the case for the Colorado squawfish, it would require alterations in drift monitoring methods depending on the flow year in question.

7. What effects, if any, do contaminants such as agrichemicals, heavy metals, etc. have on the species' decline and prospects for its recovery? To date, knowledge of specific contaminant levels is insufficient. It should not be tacitly assumed that, as the chemical nature of the river changes, this will have no effect on the overall fitness of Colorado squawfish (and other native species).

8. Is physical habitat enhancement possible? For what life stages? Can we measure future deleterious changes in essential habitat features such as the spawning areas in lower Yampa Canyon? If recognized, can remedial action be meaningfully implemented? Can the relatively unaltered lower Yampa River be used as a model for corrective efforts elsewhere?

9. Are effective methods available for exotic species management?

10. Can migrational barriers be altered to permit bi-directional passage of migratory adults?

11. Is artificial propagation a meaningful tool for enhancing populations? Experience by Toney (1974) and Hamman (1981) suggests that culture is relatively easy; however, experience with an experimental release of juveniles in small ponds connected to the mainstem Colorado River (Moffat County, Colo.) resulted in heavy predation by exotics (L. Kaeding, CRFP, pers. comm.). Would it be better to release larger individuals to reduce predation mortality? Is it necessary to be concerned with maintaining the heterozygosity of genetic subpopulations under cultural conditions?

12. Unquestionably, further research on the homing hypothesis should be conducted. Experience gained with salmonid homing experimentation could be considered. If migrating adults are in fact homing to an olfactory cue, the release of artificially propagated "naive" individuals could be problematical. Further, if homing is a reality, the preservation of the chemical integrity of Yampa River seeps is critical.

Clearly, recent research by CRFP, DOW, and others has yielded important information, however, we must be willing to admit that our knowledge is largely surficial and that questions such as those above must be answered if this endemic fish is to be effectively managed.

Perhaps the most crucial research/management implication of past studies is that a coordinated research effort throughout the upper basin, based upon a critically organized and goal-oriented research design, will yield needed empirical data in the shortest possible time. It is important, however, that a realistic time frame be allocated for this work--researchers who have been involved with implementing past field studies and interpreting collected data realize all too well the difficulties of deriving meaningful information on this elusive species.

The questions and comments offered in the above synthesis have obvious broad applicability in virtually all circumstances where the recovery and management of an endangered species is an issue. Important and useful insights relative to the ecological requirements of the Colorado squawfish may be derived from knowledge of the needs of large wide-ranging predators in general, and more specifically, from research conducted elsewhere on large potamodromous cyprinids. Unquestionably, habitat alterations resulting from water resource development in the upper Colorado River basin will continue as states endeavor to develop their full entitlements under the 1922 Colorado River Compact and the 1948 Upper Colorado River Basin Compact (Bishop and Porcella 1976). These compacts insure that the upper basin deliver specified flows to lower basin states and that Utah is entitled to minimal flows from Colorado. Accordingly, the water remaining in upper basin river channels after all entitlements are met will represent the totality of potential habitat available for the Colorado squawfish and other rare Colorado River endemic fishes. If remaining flows are to provide acceptable fish habitat, they must be budgeted to provide for the species' life requisites in terms of timing, quantity, and quality. Inferences made from broadly applicable ecological knowledge can provide important guidelines for flow budgeting considerations until more species-specific information has been derived. Clearly, the highly regulated Colorado River offers continually diminishing unaltered habitat for the perpetuation of a species that evolved under vastly different ecological conditions from those which it now faces. Yampa Canyon in northwestern Colorado is one of the few remaining river reaches in the upper basin that has retained much of its pre-development (i.e., "wilderness") character and provides an excellent outdoor laboratory for investigating cause and effect relationships for this particular endangered species. In a general sense, knowledge gained to date from studies in Yampa Canyon is illustrative of the connection between the preservation of rare species and the maintenance of large wilderness areas. In the cases of the Colorado squawfish, its future throughout much of its existing range appears to be closely tied to the continuation of practices that insure the natural features of Yampa Canyon.

REFERENCES

Archer, D.L., H.M. Tyus, and R.A. Valdez. Field methodologies of the Fish and Wildlife Service's Colorado River Fisheries Project. Transactions of the Bonneville Chapter, American Fisheries Society, Vol. 1980: 13-36.

Banks, J.L. Fish species distribution in Dinosaur National Monument during 1961 and 1962. Fort Collins, CO: Colorado State University; 1964. 96 p. M.S. thesis.

Bishop, A.B., and D.B. Porcella. Physical and ecological aspects of the upper Colorado River basin in relation to energy development and environmental problems. Utah Water Research Laboratory, Utah State University; 1976. 32 p.

Colorado River Fishes Recovery Team. Colorado squawfish recovery plan. U.S. Fish and Wildlife Service. 1978. 65 p.

Ehrenfeld, D.W. The conservation of non-resources. American Scientist. 65:648-656; 1976.

Hamman, R.L. Spawning and culture of Colorado squawfish in raceways. Progressive Fish-Culturist. 43:173-177; 1981.

Haynes, C.M., and R.T. Muth. Reproduction of Colorado squawfish, Ptychocheilus lucius, in the Yampa River, Colorado (1980-83). Paper presented at 15th Annual Symposium, Desert Fishes Council, Death Valley National Monument, CA. 17-19 Nov., 1983 (in press).

Haynes, C.M., and R.T. Muth. Identification of habitat requirements and limiting factors for Colorado squawfish and humpback chubs. In: Wildlife Research Report, part 2, Nongame Investigations; Jan. 1984. Colorado Division of Wildlife, Fort Collins, CO: 177-202.

Haynes, C.M., and R.T. Muth. Downstream transport of larval Colorado squawfish in the Yampa River, Colorado (U.S.A.). (in preparation).

Haynes, C.M., T.A. Lytle, E.J. Wick, and R.T. Muth. Larval Colorado squawfish (Ptychocheilus lucius Girard) in the upper Colorado River basin, Colorado, 1979-1981. The Southwest Naturalist 29(1):21-33; 1984.

Holden, P.B. Distribution, abundance, and life history of the fishes of the upper Colorado River basin. Logan, UT, Utah State University; 1973. 59 p. Ph.D. dissertation.

Holden, P.B. Ecology of riverine fishes in regulated stream systems with emphasis on the Colorado River. In: Ward, J.V., and J.A. Stanford, eds. The ecology of regulated streams. Proceedings 1st International Symposium on regulated streams, Erie, PA. 1979. 57-54.

Kaeding, L. Personal communication. Grand Junction, CO: Colorado River Fisheries Project, U.S. Fish and Wildlife Service; 1985, Feb. 6.

Lovejoy, T. E. The epoch of biotic impoverishment. In: The endangered species: a symposium. Great Basin Naturalist Memoirs, 3:5-10; 1979.

Miller, R.R. Man and the changing fish fauna of the American Southwest, Paper, Michigan Academy Science, Arts, Letters. 46:365-404; 1961.

Minckley, W.L., and J.E. Deacon. Southwestern fishes and the enigma of "endangered species." Science 159:1424-1432; 1968.

Minckley, W.L. Fishes of Arizona. Arizona Game and Fish Department. 1973; 293p.

National Park Service. Draft wild and scenic river study and draft environmental statement. Green and Yampa Wild and Scenic Rivers. National Park Service, Denver, CO. 1979; 331 p.

O'Brien, J.S. Final report. 1983 Yampa River cobble reach morphology investigation. Fort Collins, CO: Colorado State University. Dept. Civil Eng. 1984. 78 p.

Pavlov, D.S., A.M. Pakhorukov, G.N. Kuragina, V.K. Nezdoliy, N.P. Nekrasova, D.A. Brodskiy, and A.L. Ersler. Some features of the downstream migrations of juvenile fishes in the Volga and Kuban Rivers. Journal of Ichthyology. 792:363-374; 1977.

Seethaler, K. Life history and ecology of the Colorado squawfish (Ptychocheilus lucius) in the upper Colorado River basin. Logan, Ut: Utah State University; 1978. 156 p. M.S. thesis.

Toney, D.P. Observations on the propagation and rearing of two endangered fish species in a hatchery environment. Proceedings, Western Association State Game and Fish Commissioners; 1974: 54:252-259.

Tyus, H.M. Life strategies in the evolution of the Colorado squawfish (Ptychocheilus lucius). Paper presented at: Utah's Water-Biological Symposium. September 21, 1984a. University of Utah: 14 p.

Tyus, H.M. Loss of stream passage as a factor in the decline of the endangered Colorado squawfish. P. 138-144 in Issues and technology in the management of impacted western wildlife: Proceedings of a national symposium. Thorne Ecological Institute Technical Publication No. 14. 1984b. Boulder, CO.

Tyus, H.M. Homing behavior noted for Colorado squawfish. Copeia. 1985(1):213-215.

Tyus, H.M. Personal communication. Vernal, UT: Colorado River Fisheries Project, U.S. Fish and Wildlife Service; 1985 Feb. 25.

Tyus, H.M., C.W. McAda, and B.D. Burdick. Radio-telemetry of Colorado squawfish and razorback sucker, Green River system of Utah, 1980. Transactions of the Bonneville Chapter, American Fisheries Society 1981:19-24.

Tyus, H.M., and C.W. McAda. Migration, movements and habitat preferences of Colorado squawfish, Ptychocheilus lucius, in the Green, White and Yampa rivers, Colorado and Utah. 1984. The Southwestern Naturalist 29:289-299.

United States Bureau of Land Management. Intensive wilderness inventory. Final wilderness study areas. Nov. 1980. 446p.

United States Geological Survey. Water resources data. Colorado Water year 1983. Volume 3. U.S. Geological Survey, Denver, CO. 1984. 270 p.

Valdez, R. Personal communication. Logan, Utah: Environmental Research Institute; 1985 Feb. 25.

Vanicek, C.D. Ecological studies of native Green River fishes below Flaming Gorge Dam, 1964-1966. Logan, Utah: Utah State University; 1967. 125 p. M.S. thesis.

Vanicek, C.D., and R.H. Kramer. Life history of the Colorado squawfish. Ptychocheilus lucius, and the Colorado chub, Gila robusta, in the Green River in Dinosaur National Monument, 1964-1966. Transactionsof the American Fisheries Society. 98(2):193-208. 1969.

Wick, E.J., D.L. Stoneburner, and J.A. Hawkins. Observations on the ecology of Colorado squawfish (Ptychocheilus lucius) in the Yampa River, Colorado, 1982. Colorado Division of Wildlife, Endangered Wildlife Investigations. Job Progress Report. SE-3-5 and National Park Service, Water Resource Field Support Laboratory Report No. 83-7; 1983; 55 p.

Wick, E.J., T.A. Lytle, and C.M. Haynes. Colorado squawfish and humpback chub population and habitat monitoring. Colorado Division of Wildlife Endangered Wildlife Investigations, Job Progress Report. SE-3-3. 1981; 156 p.

CONFLICTS BETWEEN WILDERNESS USERS AND BLACK BEARS

IN THE SIERRA NEVADA NATIONAL PARKS

David M. Graber

ABSTRACT: For 10 years national parks in the Sierra Nevada of California have been exploring ways to reduce conflicts between backcountry recreationists and black bears (Ursus americanus) that result in ruined trips and compromise the ecological and behavioral integrity of the bears. While conditions have not improved in that time, systematic information about incidents and bear biology, and experiments with techniques for reducing the likelihood of incidents show promise of a reasonable solution.

INTRODUCTION

Conflicts between black bears and wilderness users increased sharply beginning in the 1970s in the national parks of California's Sierra Nevada, and have continued unabated to the present time. These encounters, while rarely resulting in injury either to people or bears, often result in a loss of food and damage to important equipment many miles from a trailhead, and occasionally provoke visitors to shoot their ursine assailants. Continuing problems have generally been credited to a marked increase in the number of backpackers using the Sierra Nevada high country in the past 15 years, and a changing philosophy about the management of bears exhibited both by the National Park Service and by park visitors--especially wilderness users--that has emphasized protection over manipulation of wildlife. However, while traditional practices that included harrassment and killing bears as a means of controlling depredations seriously compromised natural ecological conditions, the ready availability of anthropogenic food in habitats that were not previously utilized by black bears poses similar threats to those conditions at well.
Research on black bears sponsored by the National Park Service began in 1974 in Yosemite National Park, and was continued in Sequoia and Kings Canyon National Parks from 1980 through 1984. Study objectives were to determine differences in ecology, physiology, and behavior between black bear sub-populations exposed to human visitors, their food, and park management practices, and control sub-populations free of such contact; to characterize the nature of black bear/human conflicts; to determine the prevalence of incident-causing bears in the contact sub-populations; to evaluate the effects of present National Park Service management programs on black bear ecology, physiology, and behavior; and to recommend alternate management strategies that would minimize the likelihood of personal injury, property damage, and loss of food to park visitors while maintaining a natural black bear population.

During that same 10-year period, the Resources Management divisions of both park units (Sequoia and Kings Canyon are administered jointly) collected substantial information about the nature and extent of conflicts between humans and bears both in frontcountry and backcountry situations, and developed strategies to reduce those conflicts. This work has led to the evolution of "Human/Bear Management" programs that continue to develop and refine the means to achieve two principal objectives: first, to restore and maintain the natural distribution, ecology, and behavior of black bears free of human influence; secondly, to minimize the threat to human safety and property.

This paper summarizes findings of our research, the Parks' management programs, and collaborative studies as they relate to conflicts between black bears and wilderness users in Yosemite, Kings Canyon, and Sequoia National Parks. We discuss options to solve conflicts and recommend a course of action.

STUDY AREA

Yosemite, Kings Canyon, and Sequoia National Parks are located on the western slope of the Sierra Nevada in California. Elevations range from 1,500 feet (500 m) in the foothills to more than 14,400 feet (4 400 m) along the Sierra crest. Major vegetation communities, arrayed principally by elevation, include oak woodland (Quercus douglasii and Q. kelloggii), chaparral (Adenostoma fasciculatum, Ceanothus spp., and Arctostaphylos spp.), mixed conifer forest (Pinus ponderosa, P. lambertiana, Abies concolor, and Sequoiadendron giganteum), subalpine forest (Abies magnifica, Pinus contorta, P. albicaulis and P. balfouriana), alpine tundra, fell fields, and barren rock.

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The bulk of all 3 parks lies above 6,600 feet (2 000 m) in elevation, and the majority of backcountry use takes place in these subalpine and alpine zones. Although data are scant prior to the last two decades, it is quite apparent that backcountry use increased dramatically during the 1960s and 1970s. For example, Yosemite recorded 78,000 visitor-nights in 1967 and 197,000 in 1975, declining slowly since that time; the pattern for Sequoia and Kings Canyon National Parks is similar, except that use has increased slightly in recent years (National Park Service, Sequoia and Kings Canyon National Parks, Yosemite National Park files).

METHODS

We captured, marked, measured, and released bears in areas with a variety of habitat types and visitor use levels in both frontcountry and backcountry zones. A subset of these were fitted with radio-transmitting collars and tracked regularly for up to 4 years. Some bears were relocated up to 25 miles (40 km) prior to release; others were destroyed intentionally or accidently in the course of research or management actions. We used fecal analysis to determine food habits and the importance of anthropogenic foods in black bear diet. Radio telemetry was used to determine home range, habitat use, and activity schedules, and to monitor bears relocated by management.

During the study period, 1974-1984, managers experimented with control of bears, and with control of visitors and their foodstuffs as means of reducing human-bear incidents (property damage and personal injury). Bear controls included capture and relocation, aversive conditioning, and intentional destruction. Food control included visitor information, regulation of food storage and disposal, and the use of several devices (cable, pole, locker, cannister) designed to physically prevent bear access to anthropogenic food and garbage. We reviewed the published and internal literature reporting these activities and their effects on incident levels. (The National Park Service uses the term "bear incident" to refer to any event in which personal injury or property damage takes place and a bear was the proximal cause. It is an adaptation of the general term "incident," anything that generates a ranger's report).

FINDINGS AND DISCUSSION

Nature of the Problem

Personal injury by black bears is relatively uncommon and rarely serious. From 1966 through 1976, the annual number of personal injuries for all of Yosemite National Park ranged from 3 to 29, an average of 13 or 1 injury per 292,000 visitors (Harms 1980); only a few of these injuries took place in the backcountry. Human nature and the evidence at hand suggest that nearly all personal injuries caused by black bears are reported.

Property damage incidents are far more common, but less well documented. For all of Yosemite National Park during the period 1966 through 1980, the number of reported incidents rose steadily from 49 to 975 in 1975, then began declining slowly for the next 5 years (Harms 1980; Annual bear management and incident report, Yosemite National Park, Natl. Park Serv., U.S. Dep. Inter., 1980). Backcountry incident numbers for the Sierra Nevada national parks are unavailable prior to 1975. Since then, reporting has varied in its manner of collection and hence its consistency, accuracy, and comparability. For the period 1976 through 1979, Keay and van Wagtendonk (1983) calculated that only 8-11% of actual backcountry bear incidents were reported. Thus the average annual number of reported incidents for this period, 260, may represent between 2,000 and more than 3,000 incidents (fig. 1). The average dollar loss per incident was $31. The average number of visitor-nights during that period was 167,480 (fig. 1); thus there were 644 visitor-nights per reported incident. During the years 1980 through 1984, that ratio declined somewhat to 405 (Annual bear management reports, Yosemite National Park, Natl. Park Serv., U.S. Dep. Inter., 1981-1985). From 1982-1984 in Sequoia and Kings Canyon National Parks, a period of relatively consistent reporting procedures, reported backcountry incidents ranged from 251

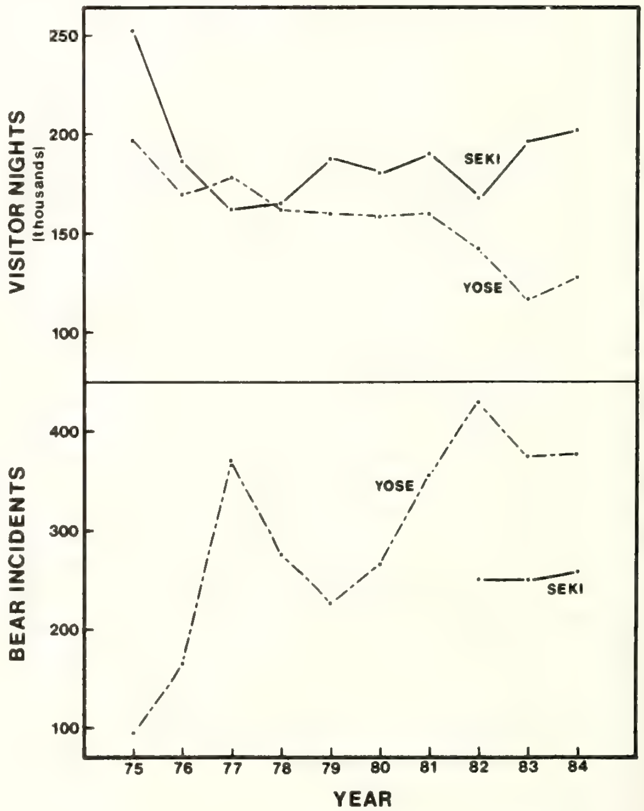

Figure 1.--Visitor nights and bear incidents reported for the backcountry of Yosemite (YOSE) and Sequoia-Kings Canyon (SEKI) National Parks, 1975-1984.

to 258, with an average dollar value per incident of $34. Average visitor-nights for that period were 189,042, or 747 visitor-nights per incident (Bear management reports, Sequoia and Kings Canyon Natl. Parks, Natl. Park Serv., U.S. Dept. Inter., 1983, 1984). Reported values for both backcountry visitor-nights and incidents are only approximate indices of actual numbers.

The Basis for Conflict

Black bears have evolved to exploit patchy food resources in a forest environment (Herrero 1978). Despite a largely vegetarian diet, bears are modified carnivores that require relatively high-quality foods; these tend to be localized. As a consequence, bears spend proportionately more time searching for food than consuming it once is found. As excellent climbers, they have a ready escape mechanism, unlike brown/grizzly bears (*Ursus arctos*). Although they are basically shy, black bears are intelligent and powerful animals that have a well-demonstrated capacity to use both of those attributes in their search for food and other aspects of survival.

Human food is the basis for nearly all conflicts between human beings and black bears that take place in native bear habitat (Graber 1981). The well-documented history of grizzly bear attacks on people, motivated by perceived self-defense, defense of young, or the intention of consuming human victims has been only rarely paralleled by black bears (Herrero 1985). Anthropogenic food in most North American bear ranges represents a nutritional resource containing digestible energy, protein, and other nutrients in a concentration usually unavailable in the wild (Goldsmith and others 1981, Graber 1981). Moreover, this concentrated food resource often presents a relatively low cost of acquisition in terms of energy expended finding and consuming it. Recreational wilderness users are not randomly and thinly distributed across the landscape, but rather predictably select favored spots (van Wagtendonk and Coho in press). Once identified, these locales represent a low search cost for bears, and an excellent likelihood of obtaining food during the recreation season. In national parks, where hunting and loaded firearms are prohibited and visitors tend to be sympathetic to wildlife, the risk to bears of capturing food from people is low.

Ecological Effects of Wilderness Users on Black Bears

Grinnell and Storer (1924) found black bears in Yosemite a rarity above 7,900 feet (2 400 m); today bears are regularly reported above 9,800 feet (3 000 m). The great preponderance of backcountry incidents are reported from less than 10 sites annually in each of the 2 park management units, but this is not a particularly accurate estimator of black bear distribution. However, we found that in subalpine and alpine vegetation types, black bear scats were restricted to the immediate neighborhood of popular camping areas (Graber and White 1983). Although anthropogenic food remains constituted only 22% of scat volume at elevations above 7,900 feet (2 400 m) (overall park mean = 15%), the relatively low nutritional value of the remainder, and the distribution of the scats themselves, suggested that anthropogenic nutrients were critical to bear diet there. In these high elevations (where most camping takes place in the Sierra Nevada), sites plagued by incidents vary from one year to the next. One explanation is that a site may support only one adult or a family group; these may die or move, leaving that site unexploited for a time.

Keay and van Wagtendonk (1983) found that in Yosemite backcountry, visitor density correlated strongly with bear incidents. They proposed that increased visitor use increases carrying capacity by establishing a predictable food resource, attracting and supporting bears. We concur.

The addition of anthropogenic food to black bear diet produces larger bears and a higher reproductive rate. During the years 1974-1978, adult males in Yosemite weighed 312 pounds (142 kg), females 191 pounds (87 kg); these are among the heaviest weights recorded anywhere and they represent a sample with a substantial diet of anthropogenic food. In contrast, bears in Sequoia and Kings Canyon National Parks during the years 1980-1984, when anthropogenic food was much less available, weighed only (255 pounds) 116 kg and (154 pounds (70 kg), respectively. Among those individuals that could clearly be classed as either utilizing camp food or having no contact with people, campground bears weighed more ($P = 0.07$) by 29 pounds (13 kg).

Female bears in Yosemite had a fertility rate (cubs/adult females) of 0.72, and an age at first reproduction of 4. The Yosemite population had a higher reproductive rate than is typical in national parks and other unhunted populations, a consequence--at least in part--of its higher nutritional plane (Graber 1981).

We found almost no evidence that human foods, *per se*, are physiologically harmful to bears. Two cases were reported by Park Service staff of bears dying after ingesting freeze-dried food. If they were true, the cause of death may have been either suffocation or rupture of the gastrointenstinal tract when the food absorbed moisture and expanded. A 460 pound (209 kg) male that was accidentally killed was found to have quantities of plastic, foil, and paper obstructing its intestines, but this problem apparently did not result in malnutrition.

Striking changes in activity patterns take place when black bears visit campgrounds and other sites of human occupation. Black bears typically are active in the morning and evening. While this bimodal crepuscular pattern obtained

in Sequoia National Park for bears that did not utilize anthropogenic foods, those that visited campgrounds were nocturnal and unimodal. No doubt this was an adaptation to human activity schedules designed to minimize risk when obtaining food (Ayres and others, in press).

Bear Management Options and Consequences

Relocation.--Removal of problem bears to other locations has long been a preferred tool used by many agencies, including the National Park Service. In Yosemite, where many relocations took place from 1974 through 1978, we found this practice functionally equalled a high mortality rate, probably contributing to the high reproductive rate in the remaining bears and inducing social dislocation in both contributing and recipient populations. (Graber 1981). For the period 1980 through 1984 in Sequoia and Kings National Park, only one relocated bear fitted with a transmitter successfully established a new home range away from developed areas (and abandoned it in 1985); there were 44 relocations during that period. McArthur (1981) found poor success with relocation in Glacier National Park. In wilderness situations, relocation is also extremely costly because capture effort is greatly increased and transport must be done by helicopter; actual expense may exceed $1,000. Relocation is a questionable procedure in most circumstances.

Destruction.--From an ecological standpoint, destruction of problem bears induces dislocation in only one population instead of two. Additionally, it is less expensive than relocation since bear transport costs are eliminated. Identification of problem individuals, however, generally requires one capture to mark each candidate bear, an observation period, and then location and destruction of the identified problem bear. Both relocation and destruction alter natural mortality patterns. However, since mortality rates for subadults, especially males, are already high, removal of these individuals from a population has less effect than removal of adults (Graber 1981). In the three Sierran parks, managers have destroyed bears that injured people or seemed likely to do so in the future. Neither relocation nor destruction by themselves correct the conditions that lead to bear incidents in the first place.

Aversive conditioning.--Attempts to condition black bears to avoid humans and their food in field conditions have been notably unsuccessful (Hastings and Gilbert 1981, Hastings 1982). Although food aversion might succeed in a single campground where only a few bears require conditioning and experimental conditions could be controlled, these techniques cannot be applied generally over vast wilderness areas. Resource managers in Sequoia and Kings Canyon National Parks experimented with using stones and rock-salt fired from shotguns to condition a few aggressive bears to avoid people. The treatments were difficult to apply safely and without offending visitors; the only perceived response was that some treated bears became more wily in their quest for campers' food. Denali National Park in Alaska has experimented with rubber bullets to induce fear of humans in aggressive grizzly bears (J. Dalle-Molle, pers. commun. 1984), while Miller (1983) and others have tested a variety of repellents that could be applied by backpackers. These techniques are still experimental, labor intensive, and at best may be applied to a small number of individual bears.

Human Management Options

Visitor information.--Park visitors, even wilderness users, are poorly informed about the nature of black bears and the options available to them to protect themselves and their food (Burghardt and others 1972, Baptiste and others 1979, Singer and Bratton 1980, Hastings 1982). A survey of backcountry campers in Yosemite found that although 95% had received at least a brochure about proper food control, and 92% reported their food was protected, only 3% were actually managing their food by recommended techniques (Bear management report, Yosemite Natl. Park, Natl. Park Serv., U.S. Dep. Inter. 1979). Many visitors don't know whether they are dealing with black or grizzly bears, or have a poor understanding of the differences. Although both park management units utilize extensive written and pictorial material to inform park visitors, including special handouts to those applying for Wilderness Permits, communication of the relatively complex information has best been accomplished personally. This option holds much promise so long as funding levels can support it.

Behavior around bears.--There is increasing evidence that human timidity sometimes leads to increasing aggressiveness in both black and grizzly bears (Jope 1983, McCullough 1982). In particular, readiness of people to give up their food to a bear without imposing some cost on the bear (such as yelling or throwing rocks) may encourage that individual to be bolder at the next encounter. As bold bears are more likely to provoke fear rather than combativeness in people, there is a positive feedback loop. Although after handling and observing bears hundreds of times we never encountered a situation in which my aggressiveness provoked greater aggressiveness on the part of the bear, there are certainly circumstances, especially at close quarters, in which visitors unfamiliar with bear behavior ought best apply cautious retreat. Whereas the Sierra Nevada parks five years ago advised backcountry visitors to back off from bears in a campsite and never to contest ownership of food, rangers now are cautiously suggesting to more sophisticated backpackers that there are circumstances in which careful aggressiveness is appropriate. Such instruction may provide outlet to the frustration that presently leads some backpackers to carry firearms.

Hardware solutions.--The Sierran parks presently offer five different technological means of protecting food from bears:

1. Counter-balance. Tossing a food sack and line over a high limb and tying it off to the trunk or another tree to outsmart bears no longer works in the Sierra; if a bear is physically capable of reaching food or line, the food is not secure. Counterbalancing, a technique developed in Yosemite, requires the user to carry about 70 feet (20 m) of light, strong cord, and at least one stuff sack. Two sacks or a sack and weight are balanced over a small, live limb at least 10 feet (3 m) from the trunk, with the sacks at least 20 feet (6 m) above the ground. This technique is difficult to apply; it requires dexterity and the proper kind of tree--unavailable at higher elevations. A small but possibly increasing number of bears are able to foil the system by breaking the limb or diving at the food sack from a branch above.

2. Bear-proof cable. This technique creates an artificial limb of aircraft cable suspended between two trees. Unlike the limb it will not break, and if a portion of it is sufficiently clear of vegetation above, it is easier to counter-balance and less subject to a bear leaping from above. Cables installed in all three parks have been popular with wilderness users. Bear-proof cables must be installed by park management, and maintained to correct for stretching, rusting, and the accumulation of tangled cord on the cable. They are an artificial intrusion in wilderness, and tend to aggregate campers in their vicinity. This aggregation may actually draw bears to a site, increasing the risk for those who fail to protect their food adequately.

3. Bear-proof pole. This device looks like a tall metal hat rack with hooks at the top; it is anchored in rock or concrete. A second free pole is used to hoist food sacks to the hooks. The device is constructed so that it cannot be bent or climbed by bears, and food is too high for bears to reach. Bear-proof poles were developed in Grand Teton National Park. A small number are in experimental use in Kings Canyon and Yosemite National Park wildernesses. Poles are an obvious artificial intrusion in wilderness, and tend to aggregate campers.

4. Food locker. These are heavy steel boxes that cannot be opened by bears. After experimental successes at White Wolf Campground in Yosemite (1977) and Lodgepole Campground in Sequoia (1982), the three Sierran parks are installing these lockers at most frontcountry campsites and some trailheads. Eleven food lockers installed in Little Yosemite Valley backcountry campsites were accompanied by a 61% drop in incidents there between 1979 and 1980 (Annual bear management and incident report, Yosemite Natl. Park, Natl. Park Serv., U.S. Dep. Inter. 1980), and reduced bear activity in the area as well (Hastings and Gilbert 1981). However, food lockers are expensive to purchase and install; they must be transported by helicopter. They are a physical intrusion in wilderness. Either a great many would be required, or present dispersed use would have to be replaced by designated sites.

All three fixtures--cable, pole, locker--raise legal questions about government liability for visitor safety in sites where they are provided. Imposition of traditional frountcountry safety standards in these areas would significantly compromise wilderness.

5. Food canister. This is a portable cylinder or rectangle of plastic (e.g. PVC, ABS, or Lexan), presently 8 inches (20 cm) diameter and 12 inches (30 cm) long, or 6 inches (15 cm) x 8 inches (20 cm) x 12 inches (30 cm) long, weighing 2.4-3.3 pounds (1.2-1.5 kg). The top fits flush with the container; the latch requires a tool to open; the overall dimensions are such that a black bear cannot get purchase with its teeth. Originally developed in Yosemite by B. Hastings, B. Gilbert, W. Cella, and J. Keay, versions have been field tested by staff and visitors in the three Sierran parks, and in Denali National Park, Alaska against grizzly bears, for several years. The canister can be carried inside a backpack or strapped on, or carried on packstock. Results suggest the food canister is ready to mass-produce and distribute (Field tests and users' opinions of bear resistant backpack food containers in Denali National Park, Alaska, 1982 and 1983, Natl. Park Serv., U.S. Dep. Inter., 1984; Bear-proof backpacking food-storage canister report, Sequoia and Kings Canyon Natl. Parks, U. S. Dep. Inter., 1985). At the present time this method appears to be the most promising because of its portability and minimal impact on wilderness.

CONCLUSIONS

Conflicts between backpackers and black bears in the Sierra Nevada continue to be a serious problem for both visitors and managers seeking naturally functioning wilderness ecosystems. The minimal data available suggest an equilibrium may have been established between visitor density and black bear use at the high elevations where most incidents occur. A variety of tools for reducing the numbers of bear incidents exist, but most of these impose penalties on wilderness values. At present, the bear-proof portable food canister offers the best potential for minimizing conflicts, minimizing other wilderness effects, and permitting a wild and natural black bear population in the Sierra Nevada.

REFERENCES

Ayres, Lee Anne; Chow, Leslie S.; Graber, David M. Black bear activity patterns, and modifications induced by human presence in Sequoia National Park. Int. Conf. Bear Res. and Manage. 6; [in press].

Baptiste, Mary E.; Whelan, James B.; Frary, Robert B. Visitor perception of black bear problems at Shenandoah National Park. Wild. Soc. Bull. 7(1):25-29; 1979.

Burghardt, Gordon M.; Hietala, Ronald O.; Pelton, Michael R. Knowledge and attitudes concerning black bears by users of Great Smoky Mountains National Park. Int. Conf. Bear Res. and Manage. 2: 255-273; 1972.

Goldsmith, Audrey E.; Walraven, Michael E.; Graber, David; White, Marshall. Ecology of the black bear in Sequoia National Park. Technical Report No. 1. Davis, CA: National Park Service, Cooperative Park Studies Unit, University of California, Davis; 1981. 64 p.

Graber, David M. Ecology and management of black bears in Yosemite National Park. Berkeley, CA: University of California; 1981. 206 p. Ph.D. dissertation.

Graber, David M.; White, Marshall. Black bear food habits in Yosemite National Park. Int. Conf. Bear Res. and Manage 5: 1-10; 1983.

Grinnell, Joseph S.; Storer, Tracy I. Animal life in the Yosemite. Berkeley, CA: University of California Press; 1924. 375 p.

Harms, Dale R. Black bear management in Yosemite National Park. Int. Conf. Bear Res. and Manage 4: 205-212; 1980.

Hastings, Bruce. C. Human-bear interactions in the backcountry of Yosemite National Park. Logan, UT: Utah State University; 1982. 184 p. M.S. thesis.

Hastings, Bruce C.; Gilbert, Barry K. Black bear-human interactions in Yosemite National Park, 1978-1980. Yosemite, CA: National Park Service; 1981; Report [no number]. 40 p.

Herrero, Stephen. A comparison of some features of the evolution, ecology, and behavior of black and brown/grizzly bears. Carnivore. 1: 7-17; 1978.

Herrero, Stephen. Bear attacks: their causes and avoidance. New York: Nick Lyons Books; 1985. 287 p.

Jope, Katherine L. McArthur. Habituation of grizzly bears to people: a hypothesis. Int. Conf. Bear Res. and Manage. 5: 322-327; 1983.

Keay, Jeffrey A.; van Wagtendonk, Jan W. Effect of Yosemite backcountry use levels on incidents with black bears. Int. Conf. Bear Res. and Manage. 5: 307-311; 1983.

McArthur, Katherine L. Factors contributing to effectiveness of black bear transplants. J. Wildl. Manage. 45(1): 102-110; 1981.

McCullough, Dale R. Behavior, bears, and humans. Wildl. Soc. Bull. 10(1): 27-33; 1982.

Miller, Gary D. Responses of captive grizzly and polar bears to potential repellents. Int. Conf. Bear Res. and Manage. 5: 275-279; 1983.

Singer, Francis J.; Bratton, Susan Power. Black bear/human conflicts in the Great Smoky Mountains National Park. Int. Conf. Bear Res. Manage. 4: 137-139; 1980.

van Wagtendonk, Jan W.; Coho, Paul R. Establishing and implementing trailhead quotas for the Yosemite Wilderness. Journal of Forestry; (in press).

INTERACTIONS AND ACTIVITY PATTERNS OF BISON AND PRAIRIE DOGS AT WIND CAVE NATIONAL PARK: IMPLICATIONS FOR MANAGERS

Kirsten Krueger

ABSTRACT: Two basic research projects conducted at Wind Cave are briefly summarized and some management implications arising from them are presented. The first study used exclosure experiments to investigate interactions between bison and prairie dog populations. Results indicated a mutually positive relationship and suggest that certain management decisions (especially concerning population regulation and habitat manipulation of either of these conspicuous species) should be made with this relationship in mind: actions affecting one population will likely affect the other. The second study examined bison summer activity patterns. Results showed several activity peaks and a significant increase in rut-related behavior as the season progressed. The latter was coincident with the normal peak in visitor numbers. The potential for dangerous bison-visitor contacts is greatest at this time, and several preventive actions by interpretive services and park rangers are suggested.

INTRODUCTION

Of the estimated 1,037,735 visitors to Wind Cave National Park in 1984, only 84,166 or 8.1% stopped at the Visitor Center to tour the cave, and even fewer (12,337 or 1.2%) camped overnight in the park (WCNP 1984). These figures suggest that the vast majority of visitors were day users, and observations suggest that a major goal of day users is viewing the native wildlife on such drive-through visits. It is probable that use and enjoyment of Wind Cave by this type of visitor are closely related to the accessible, conspicuous wildlife, especially bison (Bison bison) and black-tailed prairie dogs (Cynomys ludovicianus). Management decisions affecting either species are thus significant to both the animals and the park's wildlife-seeking visitors. In this paper I shall present results from two basic studies conducted at Wind Cave and suggest how management can use these results to benefit park wildlife and visitors.

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The Interaction of Bison and Prairie Dogs at Wind Cave: An Ecological Rarity

Reports of early explorations through the central plains (Lewis and Clark 1906; Fremont 1845) contain anecdotes of bison associating closely with prairie dog towns. Since the late 1940s (Osborn and Allan 1949; Koford 1958; Coppock and others 1980; Coppock and others 1983a,b) ecologists working in areas supporting populations of the two species have suggested that beyond association, some sort of interspecific relationship exists between the two species and, in extreme form (Osborn and Allan 1949), that there is an actual interspecific dependency (in this case, that prairie dogs are dependent on bison grazing and trampling to help initiate and maintain their colonies against tall, invasive vegetation, which could hide predators).

The recent findings of Coppock and others (1983a,b) indicated that forage quality, digestibility, and accessibility were all significantly enhanced on Wind Cave prairie dog towns and that perhaps there existed some sort of nutritional benefit to bison feeding on dog towns. If indeed there were an interaction present between bison and prairie dogs in the park, it would be important for managers to take such an interaction into account when making decisions regarding one species or the other. In addition, if an interaction were detected and determined to be positive, it would have great ecological significance as well. If their reported frequency in the literature is an indication (Connell 1983; Duggins 1981), positive interspecific relationships are an ecological rarity; the majority of reports concentrate on mutually negative (e.g., competition) or one-way negative (e.g., predation; parasitism) interactions.

From April through December 1983, a study was undertaken to determine whether or not there was a detectible interaction between bison and prairie dogs in Wind Cave and, if so, what the nature of the interaction was. These determinations were to be based on a manipulative experiment that examined the feeding patterns of bison and prairie dogs. Bison feeding behavior on a newly poisoned town (i.e., without prairie dogs, poisoned in fall 1982) was compared with bison feeding behavior on active prairie dog towns to assess behavioral differences in relation to prairie dog presence or absence. In the same way, prairie dog feeding behavior with and without bison was compared to characterize

any detectible differences related to the presence or absence of bison. Exclosures were used on the dog towns that excluded bison but allowed prairie dogs to move freely between the exclosed and unexclosed portions of the study areas. In addition, bison foraging was observed on portions of the park not colonized by prairie dogs to gain a baseline characterization of their feeding behavior in areas undisturbed by prairie dogs. Vegetation data [species composition, percent cover, aboveground biomass, plant part composition, and forage quality (%N)] were collected monthly from within, and adjacent to, all exclosures on all study areas to provide additional information to help explain the foraging data (fig. 1).

In the end, the results of the experiment did, indeed, indicate the ecological rarity alluded to above (Krueger, submitted). On average, the largest bison foraging groups ($p < 0.05$; t-test), the smallest nearest neighbor distances between foraging bison ($p < 0.05$; t-test), and the highest bison foraging efficiencies (bite:step ratio) ($p < 0.05$; t-test) over the period of the study occurred on active prairie dog towns, as opposed to the poisoned dog town or off-town, uncolonized areas (n = no. independent observations = 2160). Similar results for prairie dogs occurred on areas of the towns where bison concentrated their feeding activities. Nearest neighbor distances between foraging prairie dogs were less ($p < 0.05$; t-test) and prairie dog foraging efficiencies were greater ($p < 0.05$; t-test) among prairie dogs foraging in unexclosed, common bison-prairie dog feeding areas than those among the same prairie dogs foraging within exclosures that excluded bison ($n = 795$).

The forage quality data (n = no. of samples = 300) gave some clue to why this might be the case. Although forage quality was elevated on all areas occupied by prairie dogs (i.e., on both active and poisoned towns) ($p < 0.05$; ANOVA), the highest levels occurred on common foraging areas of prairie dog towns used by both bison and prairie dogs ($p < 0.05$; ANOVA). In addition, the studies of Coppock and others (1983a,b) indicate that forage digestibility (IVDDM) and accessibility (low standing dead vegetation:standing live vegetation ratio) were higher on common-use areas of dog towns than on uncolonized areas. Apparently, the best forage available for a bison or a prairie dog is on the common use areas, as opposed to areas of the park that receive little or no use, or areas that receive moderate use by either prairie dogs or bison. The significance to bison of this relatively high-quality forage is under investigation and results indicate that it can account for much of the cost of pregnancy to cows, depending on the amount of time an individual cow spends feeding on active prairie dog towns. For bulls, it appears that meeting maintenance energy requirements may be significantly easier for those feeding on active dog towns (V. Vanderhye, personal communication).

Significance to Managers: Modification of Current Practices

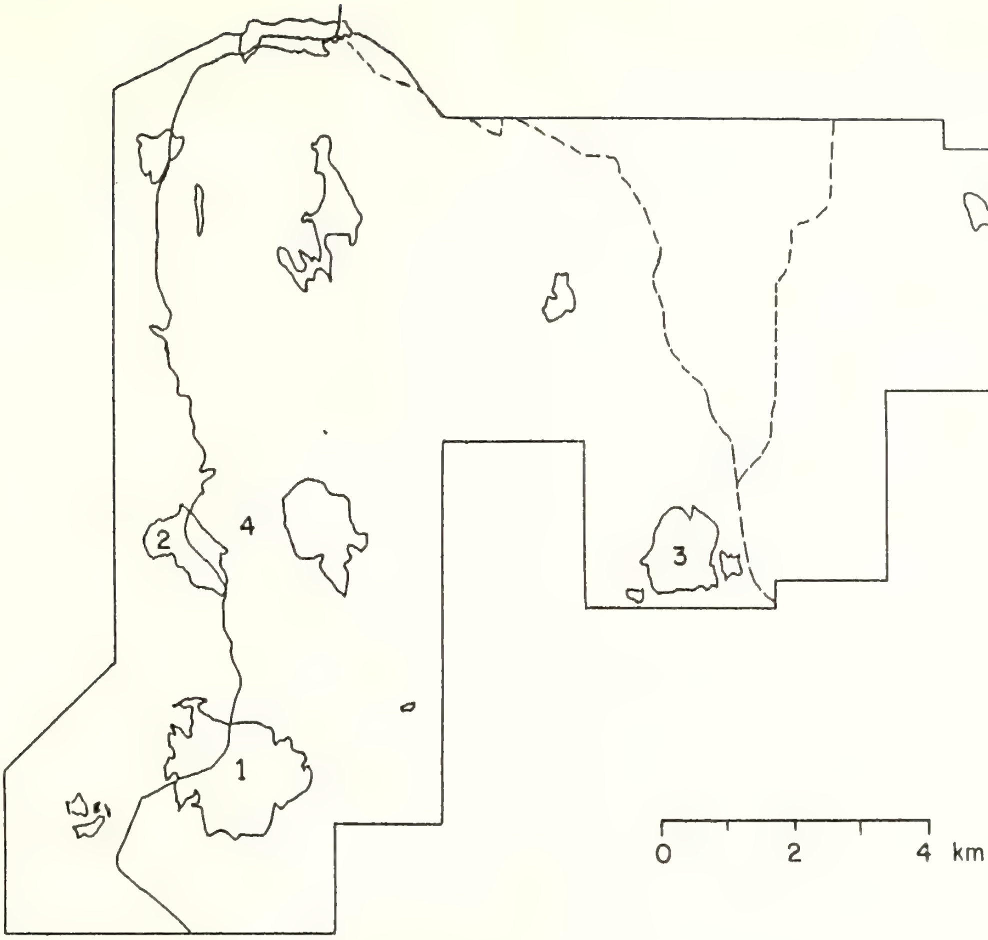
The finding of a mutually positive relationship between bison and prairie dogs at Wind Cave indicates that the populations are linked in such a way by this interaction that management actions affecting one population can very likely affect the other. As emphasized above, bison and prairie dogs are perhaps the most important wildlife resources in the park; and, in view of the current results, management actions directed at one should consider the potential consequences for the other. Prairie dog control measures have already been instituted to reduce prairie dog numbers and dog town area in order to bring prairie dog populations and the areal extent of dog towns to more "pristine" (WCNP 1982), pre-European levels. This research suggests, though does not prove, that significant reductions of this kind could limit the nutritional benefits to bison that accrue through the mutualistic relationship with prairie dogs. By the same token, bison population regulation instituted to maintain herd size within carrying capacity limits determined by the USSCS (1969) may also limit nutritional and other benefits to prairie dogs.

In addition, ongoing habitat manipulation programs such as the park's controlled burning program, can significantly influence bison habitat use and herd movements and could have short-term effects on prairie dogs similar to those of bison population regulation.

As long as healthy, conspicuous populations of these species continue to play a role in management goals or visitor satisfaction, further population control measures should be undertaken in moderation, and habitat manipulation carried out judiciously in order to maintain the bison-prairie dog mutualism.

Bison Activity Patterns at Wind Cave: Visitors Beware, Rangers and Interpreters Take Note

Although bison demeanor is normally calm, the onset, progress, and climax of the rut each year is associated with increasingly volatile and intolerant behavior, exhibited by both bulls and cows (McHugh 1958; Shult 1972; Lott 1981, personal observation). It is at this time of the year that bison behavior appears least predictable, most erratic, and, as a result, perhaps most dangerous to park visitors. The peak months of the bison rut (Shult 1972, personal observation) and the peak visitation months are generally coincident at Wind Cave [i.e., July and August (WCNP 1984)]. Many visitors specifically seek contact with bison at this critical time. A knowledge of bison summer activity patterns can assist park interpretation services in designing preventive visitor education measures and can alert park rangers to the existence of bison activity peaks and allow them to closely monitor visitor-bison contacts during these peaks.



Site	Data obtained
1. Bison Flats dog town 2. Norbeck dog town	Active dog towns provided data on prairie dog foraging behavior and vegetation characteristics in areas exclosed from bison. Additional data on prairie dog foraging behavior in areas exposed to bison foraging, and vice versa, and vegetation characteristics of common feeding areas were collected from unexclosed areas on these sites.
3. Southeast dog town	The newly poisoned dog town provided data on bison-foraging behavior and vegetation characteristics in the absence of prairie dogs. Data on vegetation characteristics of areas previously affected by prairie dogs but exclosed to bison were also collected.
4. Route 8	The uncolonized areas provided baseline data on bison foraging behavior in the absence of prairie dogs and their effects. Exclosures provided an opportunity to assess ungrazed vegetation characteristics.

Figure 1.--Bison-prairie dog interaction study sites and data collected on each site, Wind Cave National Park, 1983.

Bison activity patterns at Wind Cave during several summers provide an example. Daytime activity patterns are most relevant to the prevailing situation at Wind Cave of predominant day-only use by visitors. Clearly, the percentage of individuals active during daytime scan samples is high on average [57 to 67%, unweighted mean, data of Shult (1972) and Krueger (this paper)], although the actual pattern of activity shows rather characteristic [e.g., Ellis and Travis (1975); Green (1982)] wavelike fluctuations (fig. 2).

In addition, the observed frequency of rut-related sexual behavior (e.g., fighting, chasing, mounting, and wallowing) is significantly different than expected ($p < 0.05$, χ^2), showing marked increases over time (fig. 3). When periods of intense sexual activity overlap overall peaks in activity, the behavior of entire herd groups becomes particularly frenzied and tolerance by bison of park visitors appears especially low. The data (fig. 2) indicate that there may be several times during the day during summer months when such peaks occur. Although activity peaks for bison, as well as other large ungulates, are somewhat variable, making it difficult to predict exactly when activities will peak and thus when bison-visitor contacts might have the highest probability of producing visitor injury, significant mitigating actions can be instituted.

Significance to Managers: Recommendations for Preventive Management Efforts by Interpreters and Rangers

Knowledge of bison activity patterns (or those of any highly visible, highly attractive wildlife species) can be useful to the interpreter and park ranger alike. The negative effects to wildlife of human-wildlife contact run along an increasingly stressful scale ranging from isolated startling incidents to repeated harrassment. Such incidents are well documented for a number of species (Ream 1980; Ream 1978). Also well documented is the fact that a majority of outdoor recreationists value the opportunity to contact wildlife (Lime and Cushwa 1969). One solution to this conflict is to provide interpretation services to visitors to alert them of the potential dangers, to both themselves and the wildlife species of interest, of disturbing wild animals. This is especially important during critical periods such as the intolerant rut period of bison. According to Hendee and Schoenfeld (1978), when adequately informed, the public has shown a great willingness to yield to wildlife benefits. The data and park visitation characteristics suggest a need for an information campaign directed toward educating the drive-through visitor who is never reached by extant visitor center and campground interpretive programs. Such an information campaign (which might include waysides and traveler information stations) could benefit the visitor and park wildlife alike.

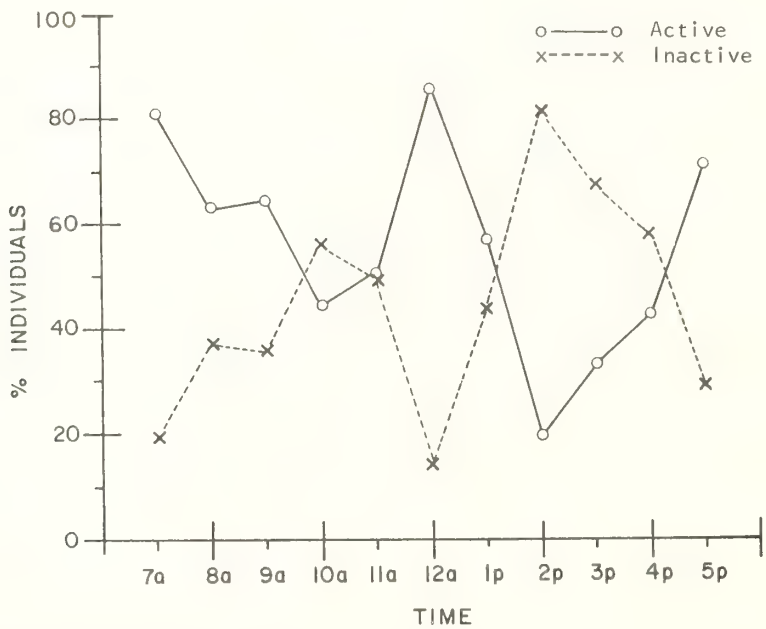


Figure 2.--Percent active and inactive bison during July daylight observations (n = 15,464 individual observations), Wind Cave National Park, 1984.

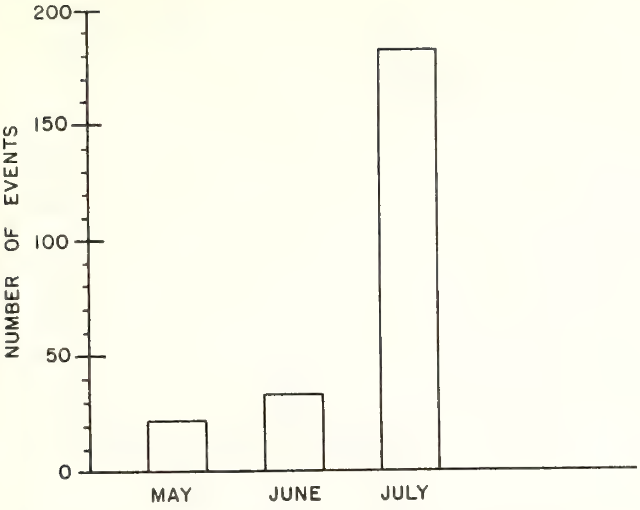


Figure 3.--Number of observations of bison sex-related behaviors during periodic daylight observation periods, Wind Cave National Park, 1984

Furthermore, park rangers can use information on wildlife activity peaks and general activity patterns in their daily park monitoring routines. At Wind Cave locating bison herd groups is relatively easy and their position in the park is generally known from day to day. When herd groups approach within sight of major highways the potential for dangerous contacts with visitors is highest. Knowing that activities will likely peak, perhaps to a frenzied state several times during the day, but not necessarily knowing when such peaks will occur, rangers can simply devote more patrol time to these high contact-potential areas along highways. This unobtrusive, yet official presence could serve to discourage visitor harrassment of bison, as well as inform visitors of the potentially dangerous situation on the spot.

Summary and Research Work Remaining and Its Relation to Management Questions

The main areas of emphasis in this paper have been as follows: (1) Wildlife populations can interact in complex and perhaps unexpected ways. The mutually positive relationship between bison and prairie dogs at Wind Cave National Park is an example of this point. (2) Management decisions affecting interactive populations should be made with such interrelationships as a dominant consideration. (3) Knowledge of activity patterns of potentially dangerous wildlife species, such as bison, can benefit visitors through preventive interpretive programs and ranger patrols modified to coincide with critical periods of contact between visitors and wildlife. These efforts can also benefit wildlife populations by decreasing harrassment.

Despite the impressive body of research that is accumulating on numerous topics at Wind Cave, an even greater expanse of unknowns remains, which involves basic ecological questions and applied questions alike. Future management decisions, especially those concerning wildlife population control, could benefit from additional research on population dynamics and population interactions which identifies and determines the variability of continuing interspecific relationships. Also, the entire subject of visitor-wildlife interactions has been virtually ignored at Wind Cave. This broad topic is an important and interesting research area that sorely needs to be addressed. The bottom line is that basic and applied research can benefit both the wildlife and visitors at Wind Cave. Moreover, an active research program in the areas outlined above can benefit managers by providing a basis for more well-informed, defensible management actions and by providing the research framework necessary for monitoring and evaluating these actions.

REFERENCES

Connell, J. H. On the prevalence and relative importance of interspecific competiton: Evidence from field experiments. American Naturalist. 122: 661-696; 1983.

Coppock, D. L.; Detling, J. K; and Dyer, M.I. Interactions among bison, prairie dogs and vegetation in Wind Cave National Park. 1980. Unpublished final report to the National Park Service, Wind Cave National Park, SD.

Coppock, D. L.; Detling, J. K; Ellis, J. E; and Dyer, M.I. Plant-herbivore interactions in a North American mixed-grass prairie. I. Effects of black-tailed prairie dogs on intraseasonal aboveground plant biomass and nutrient dynamics and plant species diversity. Oecologia. 56: 1-9; 1983a.

Coppock, D. L.; Ellis, J. E.; Detling, J. K; and Dyer, M.I. Plant-herbivore interactions in a North American mixed-grass prairie. II. Responses of bison to modification of vegetation by prairie dogs. Oecologia. 56: 10-15; 1983b.

Duggins, D. O. Interspecific facilitation in a guild of benthic marine herbivores. Oecologia. 48: 157-163; 1981.

Ellis, J. E.; and Travis, M. Comparative aspects of foraging behavior of pronghorn antelope and cattle. Journal of Applied Ecology. 12: 411-420; 1975.

Fremont, J. C. Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North Carolina in the years 1843-'44. Report to United States Senate. Washington, D.C.: Gale and Seaton, Printers; 1845.

Green, R. A. Elk habitat use and activity patterns in Rocky Mountain National Park, Colorado. Fort Collins, CO: Colorado State University; 1982. 156 p. M.S. thesis.

Hendee, J. C.; and Schoenfeld, C. Wildlife in wilderness. In: Hendee, J. C.; Stankey, G. H.; and Lucas, R. C., eds. Wilderness management. Misc. Publ. No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978: 244-247.

Koford, C. B. Prairie dogs, white faces, and blue grama. Wildlife Monograph No. 3. Bethesda, MD: The Wildlife Society; 1958. 78 p.

Krueger, K. A. Feeding relationships among bison, pronghorn and prairie dogs: An experimental analysis. Ecology. (submitted).

Lewis, M.; and Clark, W. Original journals of the Lewis and Clark expedition, 1804-1806. In: Thwaites, R. G., ed. Original journals of the Lewis and Clark expedition, 1804-1806; 1906. New York, NY: Antiquarian Press, Ltd.; c. 1959 (reprint).

Lime, D. W.; and Cushwa, C. T. Wildlife esthetics and autocampers in the Superior National Forest. Research paper NC-32. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1969. 8 p.

Lott, D. F. Sexual behavior and intersexual strategies in American bison. Zoologische fur Tierpsychologie. 56: 97-114; 1981.

McHugh, T. C. Social behavior of the American buffalo (Bison bison bison). Zoologica. 43: 1-40; 1958.

Osborn, B.; and Allan, P. F. Vegetation of an abandoned prairie dog town in tallgrass prairie. Ecology. 30: 322-332; 1949.

Ream, C. H. Human-wildlife conflicts in back country: Solutions. In: Potter, D. R.; Agee, J. K.; and Anschell, S., eds. Proceedings, Conference on recreational impact on wildlands; 1978 October 27-29; Seattle, WA; 1978: 153-163.

Ream, C. H. Impact of backcountry recreationists on wildlife: an annotated bibliography. Gen. Tech. Rep. INT-84. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 62 p.

Shult, M. J. American bison behavior patterns at Wind Cave National Park. Ames, IA: Iowa State University; 1972. Ph.D. dissertation.

United States Soil Conservation Service. Conservation plan for Wind Cave National Park, South Dakota. Washington, DC: U.S. Department of Agriculture; 1969.

Wind Cave National Park. Prairie dog management plan (WICA-N-0001). Wind Cave National Park files, South Dakota; 1982.

Wind Cave National Park. Superintendent's annual report: 1984 highlights. Wind Cave National Park files, South Dakota; 1984.

EVALUATION OF BEAR-RESISTANT FOOD CONTAINERS FOR BACKPACKERS

John Dalle-Molle, Michael A. Coffey and Harold W. Werner

ABSTRACT: Portable food containers carried by backpackers were evaluated during 1982-1985 for their resistance to opening by black and grizzly bears and for their acceptance by backpackers. Containers were used by 1618 parties for 5535 user-nights. Bears failed to open containers in 89 attempts, sniffed or licked them 24 other times, and opened containers 20 times. Ninety one percent of parties who were asked to use containers did so. Use of container's in Denali National Park, Alaska helped reduce the incidence of bears obtaining backpackers' food by 74%.

INTRODUCTION

In the past 20 years, human use of wilderness areas has increased two and a half times (Lucas 1983). At the same time, conflicts between people and black bears (Ursus americanus) and grizzly bears (U. arctos) in remote areas have steadily increased, often related to bears attracted to human food (Singer and Bratton 1980; Harms 1980; Hastings and Gilbert 1980; Singer 1982; Hoak and others 1983; Keay and Van Wagtendonk 1983). Bears quickly learn to associate human food with campers and become "habituated, food-conditioned" bears, and subsequent encounters with people often lead to property damage and occasional injuries (Herrero 1985). Wild populations of bears are an essential part of many wilderness areas. Altering natural bear behavior and numbers by providing artificial foods seriously lessens wilderness values.

Increased efforts have been made to educate backcountry campers to use proper techniques to prevent bears from obtaining human foods. However, food sometimes is not properly secured even when people are knowledgeble (Chester 1976; Cella and Keay 1980; Sundstrom 1983). In other cases, proper food storage methods do not always work or cannot be used. In some areas, bears have learned to remove food properly hung between trees (Harms 1980). Trees are too short or absent in other areas. Both permanent and portable bearproof containers have been recommended for backcountry use (Harms 1980; Hastings and others 1981; Hoak and others 1983).

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Facilities installed in some backcountry areas to reduce bear problems include cables strung between trees from which food sacks can be hung, bear poles (single metal poles with hooks on top from which food sacks are hung), metal food lockers, and fenced campsites. These methods have not always been successful in preventing bears from obtaining human foods. Also, as facilities, they are not acceptable in some wilderness areas. Finally, they can only be used in established camps where people will be sure to camp, and campers must comply with their use. But many backcountry areas have significant dispersed use where established campsites do not exist. An easily portable method of securing food is required to meet all these needs.

Hastings and others (1981) experimented with portable containers in Yosemite National Park and concluded they would have excellent potential if they were further tested and developed. The staff of Yosemite National Park continued to develop containers prior to our involvement. B. Gilbert and B. Hastings pioneered container development and B. Cella and J. Keay continued design advances. We report here on our 1982-1985 development and testing of lightweight bear-resistant food containers that backpackers can carry. We thank R. Garcia, J. Penn, M. Benke, F. Singer, K. Jope, J. Van Horn, B. Shults, D. Waring, the San Francisco Zoo and the Roeding Park Zoo, Fresno, for help.

OBJECTIVES

1. Determine opinions of backpackers toward the design of the containers and their willingness to use them.
2. Test the degree of resistance to opening of containers by free-ranging black and grizzly bears.
3. Document bear behavior toward containers and observe how bears open containers in order to improve design and construction.

STUDY AREAS

Denali National Park and Preserve is located in southcentral Alaska and covers 9,416 mi^2. Elevations range from 400 to 20,320 ft. Over half of Denali is mountainous terrain, much of which is shrub and tundra vegetation without trees. The majority of backcountry use occurs in such terrain, is dispersed, and is within designated wilderness. Both black and grizzly bears inhabit Denali, although most backcountry use is in grizzly habitat. Grizzly density for the area most used by packpackers is 1 bear/13 mi^2 (Dean 1976, 1984).

Figure 1.--Some containers tested so far. From left, models L89, L8612, L8812, 806, 802, 801, and PVC 29.

Sequoia and Kings Canyon National Parks are adjacent to each other in southern California and are administered as one unit. They total 1,350 mi^2, most of which is designated wilderness. Elevations are 1,280 to 14,494 ft. Most of these parks is conifer forested with the remainder being chaparral, woodland, meadows and rock. Black bears are found mainly below 9,000 ft.

METHODS

Several models were developed and tested (fig. 1), but we report only on the most recent, improved ones (table 1). All were made primarily of plastic materials. Model 802 has a metal double push-button lid-latching system. Model 806 has a lid fastened by a metal cam-lock that is rotated once about 360° by placing a coin, knifeblade, key or similar object in a slotted head and turning. The Lexan models have a modified metal cam-lock that is turned the same way but must be rotated several times to tighten the cam in place.

Zoo Tests

Containers were first tested with zoo grizzly bears. Containers were baited with fish oil and placed in the enclosure with the bear. The bears' behavior toward the container was recorded until it apparently lost interest or was successful in breaking in. Tests often resulted in new models being designed or in design changes on existing models.

Field Tests

Containers were baited with fish oil and/or other odorous food and placed upwind of free-ranging bears so the scent would be carried to the bears. The bear's behavior toward the containers was recorded until the bear lost interest or was successful in breaking into it. If a bear was successful, it was chased off before it could obtain a food reward.

Containers were also distributed to backpackers at trailheads and visitor information stations. Distribution was not random because we wanted to test our limited supply of containers in the areas that had the highest number of bear problems. A

Table 1.-- Specifications of bear-resistant food containers used in tests

Model	Material	Style	Dimensions	Weight (lb)	Weight (oz)	Capacity (in^3)
802	black ABS	cylinder	8"x13"	4	7	653
806	black ABS	cylinder	8"x12"	3	4	603
L89	clear Lexan	cylinder	8"x9"	3	6	452
L8612	clear Lexan	rectangle	8"x6"x12"	2	10	576
L8812	clear Lexan	rectangle	8"x8"x12"	3	10	768

brief explanation of the container program was given, as well as standard safety procedures to follow in bear country. A survey form was started on the backpacking party and when they returned they were asked their opinions on several aspects of container design and use. If a bear approached their camp, further questions were asked regarding bear behavior toward the containers. Parties unwilling to use the containers were recorded as "nonusers." Halfway through the test program, backpackers in some zones in Denali were required to use containers as part of their backcountry permit stipulations. If they chose not to, they were routed to zones not requiring containers.

RESULTS

During 1982-1984, containers were used by 1618 parties for 5535 user-nights. Denali had 1281 parties for 4593 user-nights, while Sequoia and Kings Canyon had 337 parties for 942 user-nights. Denali's much larger test was possible because of a larger stock of containers and the relative ease of contacting backpackers, most of whom enter and leave the park at one contact station.

Backpacker Survey

Reactions to the containers, after using them for backpacking, are shown in table 2.

Overall evaluation -- Users were positive toward the container idea; only less than 2% thought it was a poor idea. There was no real difference in approval between models 802 and 806 (X^2=1.8, 1 df, P=0.82) despite a 19 oz. weight difference.

Table 2.-- User opinions of bear-resistant food containers

	Sequoia & Kings Canyon	Denali
	Percent	
Overall	(N=281)	(N=1104)
Good idea	98	98
Poor idea	1	2
Use again	(N=274)	(N=1119)
Same design	66	70
Different design	26	26
No	8	4
Weight	(N=258)	(N=1132)
Ok	64	67
Too heavy	36	33
Size	(N=254)	(N=1302)
Ok	75	78
Want smaller	15	14
Want larger	10	8
Shape	(N=274)	(N=1098)
Ok	73	80
Want rectangular	12	11
Want other	15	9
Latch system	(N=264)	(N=1090)
Ok	86	92
Other suggestions	14	8

Nine percent of those asked to carry containers (N=1523) declined. At Denali, only 4.6% declined, with 66% of those stating that the containers were too heavy. Most of these nonusers were only offered model 802, the heaviest one. At Sequoia and Kings Canyon, 41% of those inquiring about containers declined (N=180). Several nonusers in all three parks volunteered to use containers under different trip situations or if lighter ones were available.

Willingness to use again.--Of the users, 68% were willing to use the same models again, while 26% would use a different model, and 6% would not use any. There was no difference in willingness to use models 802 or 806 (X^2=0.90, 1 df, P=0.65).

Weight.--Weights were satisfactory to 66% but too heavy to 35% of the users. Significantly more users of model 806 approved its weight than did users of the heaver 802 model (X^2=6.2, 1 df, P=0.98).

Size.--Container sizes were approved by 77% of the users. Fifteen percent wanted smaller containers, while nine percent wanted larger ones.

Shape.--Seventy-seven percent of the users were satisfied with the shapes of the containers. Almost 12% of the users of cylindrical models would have liked a rectangular shape, while only a few who used the rectangular models wanted cylindrical ones.

Latch systems.--Users were highly satisfied with the latches; 89% approved them. There was no difference between approval of the cam-lock and push-button systems (X^2=0.74, 1 df, P=0.61).

Carrying system.--None of the containers initially had strap holders for securing containers on the outside of packs. Many users preferred to use straps than place the container inside their pack. We did not survey users about carrying systems, but many commented on the need for strap holders. Model 802 has protruding rims which prevents a container from sliding out of straps, but the other models are smooth-sided. We installed strap holders on some containers as a result of the early comments and did not experience problems or negative comments.

Care of containers.--User care of containers is considered an indication of program acceptance, as well as a useful measure of maintenance costs. Although 16% of the containers (N=876) were considered dirty upon return, most were only slightly so. Two containers were broken by misuse and nine were reported lost, stolen or were never returned.

Willingness to buy or rent.--Half who responded to this question (N=766) were willing to pay at least \$10.00 for a container and 32% would pay at least \$15.00. In Denali 19% were unwilling to purchase containers (question not asked in Sequoia). Also in Denali 20% (N=728) were not willing to rent containers, 27% would rent for up to \$.50/day, 38% for up to \$1.00/day and 27% for up to \$2.00/day.

Compliance with use.--In a sample of 60 parties throughout Denali who had containers checked out, we found only one party that did not actually take the container. This party had canned food only and felt they did not need the container.

Bears' Behavior Toward Containers

Zoo tests.--The most recent container models withstood considerable efforts by zoo grizzly bears to break in (table 3). Only a 1,400-lb grizzly was able to break a container. Bears bit, stood on, pawed, embraced, rolled and even dropped containers from a six-foot height. Several times they threw one 15 feet against the concrete walls. Only after containers passed most of the zoo tests were they used in our field tests.

Table 3.-- Final tests of bear-resistant food containers with zoo grizzly bears, before containers were accepted for field and user tests

Model	Bears' Weight (pounds)	Test Duration (minutes)	Results
802	300	20	tooth marks
802	450	20	tooth marks
806	600	20	tooth marks
806	700 720	40	tooth marks
806	1400	10	cracked container
L8612	650	70	tooth marks
L8612	700 800 900	80	tooth marks largest bear carried container in mouth.

Field tests.--Bears attempted to break open containers 89 times (table 4), only sniffed or licked containers 24 times and ignored containers 12 times. In addition, we sent two model 806 containers to Katmai National Park, Alaska. Grizzly bears there attempted unsuccessfully to open containers twice and once only sniffed (K. Jope, pers. comm.). Of the 20 successful openings of containers, grizzlies chewed into two model L8612 containers. Seven containers were opened due to a manufacturing defect in one batch of model 806 when lid tab glue joints failed. We made considerable effort to break this joint on other batches without success. In two cases, users overpacked model 806 containers so the lids bulged out enough to allow bears to pull the lid up with a claw. Newer versions of model 806 have three cam-locks instead of one so this can no longer happen. In the remaining nine of the 20 openings bears got into containers in unknown ways but evidence indicates the lids were not latched. Bears also got food from containers four times when the lids were known to be unlatched. This usually happened when people were cooking and a bear suddenly appeared. In a few similar cases, the campers had the presence of mind to place their food in the containers, secure the lids and then leave. In these instances, the bears were not able to break in. Although bears sometimes moved containers and in a few cases users accidently caused the containers to roll downslope, no containers were lost this way.

Table 4.-- Reactions of bears to containers when bears were aware of container

	Black bears		Grizzly bears
	Sequoia[1]	Denali	Denali
	--------Number (%)--------		
Unsuccessful Openings	61(76)	2(100)	26(41)
Successful openings	13(16)		7(11)
Sniffed or licked only	3(4)		21(33)
Ignored container	3(4)		9(14)

[1] Does not include 1985 Sequoia/Kings Canyon data.

Behavioral learning theory suggests that, if prevented by such means as containers, bears that are conditioned to obtaining food from people may redirect their efforts to stimuli associated with past human food rewards, and so they may aggressively approach people or their equipment (McCullough 1982). None of our bears exhibited such aggression while still in or near the sites after they had been unsuccessful with containers. However, since they were unmarked bears, we were not able to determine their later behavior. But a reduction of 31% in bear/people conflicts in Denali during 1982-1984 (Van Horn and Dalle-Molle 1984), and a 74% reduction in bears obtaining human food in the backcountry of Denali during 1982-1985, suggests that bears have lessened their activity and aggression toward people and equipment.

DISCUSSION

Container model 806 has been the most successful model, once we added strap holders and two additional cam-locks. For most areas with bear problems, model 806 should be adequate to reduce bears' obtaining human food. However, no container is likely to be absolutely bear-proof, even when properly used. Most of the free-ranging bears that tested our containers were relatively small (100-250 lb). Those in Sequoia/Kings Canyon are very experienced in obtaining hikers' food, but the containers generally foiled them. The zoo tests helped detect many problems but not all. The only uncorrectable container model failures we had during field tests were the model L8612 containers that were chewed into, after having passed zoo tests with much larger bears.

Users' opinions on all aspects of the containers were very similar between Sequoia/Kings Canyon and Denali. Containers were very strongly supported by those who actually used them. The high proportion of backpackers at Sequoia/Kings Canyon who declined to use them indicates a need for a better distribution system and/or for a better way to convince backpackers of the value of the containers

in preventing bear problems. When containers were required in certain areas of Denali, nonuse dropped to less than one percent with few complaints.

Weight was the main dislike. Unfortunately, we had only a small number of the lightest model, L8612, and were unable to obtain a large enough sample of opinions about it to determine if it was significantly more acceptable than the heavier models. However, the fact that so many people were willing to use the heaviest containers despite their dislike of the weight is an indication that we should be able to lower the nonuser rate by offering lighter models.

Some backpackers initially were unwilling to use containers because of their bulk; the volume capacity was more than they needed. When we suggested they fill unused container space with nonfood items to reduce the bulk in their packs, they almost always agreed to use the containers. There was a slightly greater preference for rectangular shapes, but the available shapes did not influence whether a person would or would not use a container. Strap holders are definitely needed to attach containers to packs. Many more people than we initially expected preferred to carry the container outside their packs than inside.

For most backcountry areas that might find these containers useful, logistics likely would be the biggest problem. Area staffs may not be sufficient to distribute and receive containers. Ideally, users should be able to buy containers from outdoor suppliers. However, the current experimental models are individually made and cost $50.00 or more. In order to encourage widespread purchases, the cost will likely have to be at least half of that, with strong information programs to convince backpackers of the need for their use. Some people who visit bear areas infrequently may not be willing to invest in a container. Rentals from outdoor stores may be possible, but the size of the containers may likely restrict the number of retailers who are willing to stock them. Further research is needed to develop stronger, yet lighter mass-produced containers (such as from a molding process) that would be inexpensive for backpackers, yet have enough profit margin to attract retailers to stock them.

In certain situations, model 806 now can be used operationally. For example, in Denali, low human use levels, strong visitor support, simple logistics, and lack of alternatives, have resulted in the containers now becoming an operational part of bear/human conflict management. Use of the containers by most backpackers in many areas of Denali has been the key to the 74% decrease in bears obtaining human food during the first four years of the container program.

REFERENCES

Cella, Brad; Keay, Jeff. Annual bear management and incident report, Yosemite National Park, 1979. Yosemite National Park, CA: National Park service; 1980. 22 p. Unpublished report.

Chester, James M. Human wildlife interactions in the Gallatin Range, Yellowstone National Park, 1973-1974. Bozeman, MT: Montana State University; 1976. 114 p. M.S. Thesis.

Dean, Fred C. Aspects of grizzly bear population ecology in Mount McKinley National Park. In: Pelton, M.R; Lentfer, J.W.; Folk, G.E., eds. Bears - their biology and management: Papers of the third international conference on bear research and management; 1974 June; Binghampton, NY. International Union for the Conservation of Nature and Natural Resources. 1976: 111-119.

Dean, Fred C. Brown bear density in Denali National Park 1983. Denali National Park AK: National Park Service; 1984. 35 p. Unpublished report.

Harms, Dale R. Black bear management in Yosemite National Park. In: Martinka, Clifford J.; McArthur, Katherine L.; eds. Bears - their biology and management: Papers of the fourth international conference on bear research and management; 1977 February; Kalispell, MT. Bear Biology Association Conference Series No. 3; 1980: 205-212.

Hastings, Bruce C.; Gilbert, Barrie K. Aversive conditioning of black bears in the backcountry of Yosemite National Park. In: Proceedings of the Second Conference of Scientific Research in National Parks; 1979 November 26-30; San Francisco: 478p. available from: NTIS, Springfield, VA 22161; paper copy $33.50, Microfiche $3.50; PB81-100083; 1980; 7:294-303.

Hastings, Bruce C.; Gilbert, Barrie K.; Turner, David L. Black bear behavior and human-bear relationships in Yosemite National Park. Davis, CA: University of California at Davis, Cooperative Park Studies Unit; 1981; Technical Report No. 2. 42 p.

Herrero, Stephen. Bear attacks. Piscataway, NJ: Winchester Press; 1985. 287 p.

Hoak, John H.; Clark, Tim W.; Weaver, John L. Of grizzly bears and commercial outfitters in Bridger - Teton National Forest Wyoming. In: Meslow, E. Charles, ed. Bears - their biology and management: Papers of the fifth international conference on bear research and management. 1980 February; Madison, WI. International Association for Bear Research and Management. 1983: 110-117.

Keay, Jeffrey; van Wagtendonk, Jan W. Effect of Yosemite backcountry use levels on incidents with black bears. In: Meslow, E. Charles, ed. Bears - their biology and management: Papers of

the fifth international conference on bear research and management. 1980 February; Madison, WI. International Association for Bear Research and Management. 1983: 307-311.

Lucas, Robert C. The management of recreational visitors in wilderness areas in the United States. In: Bayfield, N.G.; Barrow, G.C.; eds. The ecological impacts of outdoor recreation on mountain areas in Europe and North America. Recreation Ecology Research Group Report No. 9. R.E.R.G., Wye, England. 1983: 122-137.

McCullough, Dale R. Behavior, bears, and humans. Wildlife Society Bulletin; 10(1): 27-33; 1982.

Singer, Francis J. Problem analysis - grizzly bear management Denali National Park. Anchorage: National Park Service: 1982. 35p. Unpublished report.

Singer, Francis J.; Bratton, Susan Power. Black bear/human conflicts in the Great Smoky Mountains National Park. In: Martinka, Clifford J.; McArthur, Katherine L., eds. Bears - their biology and management: Papers of the fourth international conference on bear research and management; 1977 February; Kalispell, MT. Bear Biology Association Conference Series No. 3; 1980: 137-139.

Sundstrom, Thord C. An analysis of Denali National Park and Preserve's management program to educate visitors regarding behavior while in bear country. Laramie, WY: University of Wyoming; 1984. 291 p. M.S. Thesis.

Van Horn, Joseph; Dalle-Molle, John. Denali Bear/Human Conflict Management 1984. Denali National Park, AK: National Park Service; 1984. 26 p. Unpublished report.

Section 5. Wilderness Water Research

OVERVIEW OF THE SESSION ON WATER

Robert Aukerman
Session Coordinator

Water resource problems and their solutions in wilderness require research and input from a variety of disciplines. The research papers from the wilderness research sessions on water therefore cover a broad range of topics from recreation use and preception to physical and biological monitoring to water quality and ecosystems protection.

What is apparent from a wilderness water view is that anything done in the name of management, use, and related research in wilderness will probably have some tie to water. What is apparent from a water resources research view is that water has received considerable attention since the early 1960's and there now exists a considerable body of knowledge which can be applied to the problem of wilderness areas. The real questions are: What are the most important problems of wilderness related to water, and are there some basic data that need generating?

Certainly there are some basic data needs, some of which are demonstrated from the papers presented in this section. However, the focus of future research is still not clear from our water session. It is my belief that the future focus of wilderness water research should be based upon the premises that water is a very limited resource, it is the focal point of outdoor recreation and is in ever-increasing demand from a variety of consumptive, polluting, and competing uses. Therefore, the greatest role wilderness can have is in helping protect our Nation's waters and their environs from overuse, pollution, and consumption. This means preservation of some waters in their natural states, and the protection of entire watersheds and ecosystems. The unique ability of wilderness to do this lies in the strength of the concepts of wilderness for preservation of resources in their natural state. For water, this means that the concepts, policies, and legal influences of wilderness must go beyond wilderness boundaries.

Industrial pollution, acid mine drainage, sewage and waste disposal, acid rain, surface and ground water removal and depletion, and damming of rivers all are major water problems which endanger wilderness yet are created mainly outside of wilderness boundaries. Therefore, the greatest challenge to managers and supporters of wilderness from a water standpoint is to protect wilderness against these outside influences. The battle will be in the courts of law and will be won or lost based upon <u>values</u> of society and <u>facts</u>.

What this means from a water research standpoint is that what is needed most to protect wilderness and water is research that will produce facts. Facts are needed that will demonstrate changes from natural conditions in water quality and quantity, and tie those changes directly to those who are responsible for them. What is needed are baseline data and ongoing monitoring programs within and outside of wilderness boundaries that produce scientifically sound data on water users and their effects on the quality and quantity of water ecosystems.

Armed with this researched base of knowledge, we can then fight the legal battles to protect the wild and natural resources that are so essential to mankind.

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VEGETATION, SOIL, AND WATER MONITORING IN PROPOSED WILDERNESS

OF THE INLAND EMPIRE OF THE PACIFIC NORTHWEST

Paul R. Saunders and Richard L. Shew

ABSTRACT: Baseline monitoring studies have been started in alpine and subalpine cirque basins of proposed wilderness using techniques adaptable to wilderness managers. Monitoring of vegetation, soils, and water can be conducted at the technician level, but soil and water analysis require exacting laboratory conditions. Vegetation monitoring best describes changes that occur with establishment or growth of existing campsites. Soil monitoring best describes changes during site establishment, and has the potential to describe changes from continued use. Monitoring water pH and conductivity will indicate if changes are occurring to the cirque lakes, but detailed analysis is needed to determine the nature of change and its tie to dispersed recreational use.

INTRODUCTION

Recent major land use laws such as the Forest and Rangeland Renewable Resources Planning Act of 1974, National Forest Management Act of 1976, and Federal Land Policy and Management Act of 1976 require ongoing, in-the-field monitoring, and subsequent evaluation or assessment of observed changes. Detailed monitoring and assessment procedures are to be incorporated into each land management plan. Monitoring is a systematic means of studying key ecosystem elements to determine the impacts of management and use on those elements. Assessment is interpretation of monitoring data so that necessary adjustments can be made to achieve management goals and objectives (Saunders 1985).

Wilderness use, one form of dispersed recreation, occurs on wildlands. Therefore, an ecosystem approach (Odum 1971; Alden 1973) is required to identify key ecosystem elements, monitor those elements, and assess effects of use and management on wildland ecosystems. Water is the life blood of an ecosystem, providing moisture and transporting nutrients. Within water are myriads of single- and multicellular organisms, each living in a narrow range of temperature and water chemistry. On land are plant communities composed of species sensitive to changes in light regimes, nutrient status, trampling, and increased soil bulk density (Cole and Schreiner 1981). Loss of vegetation cover leads to soil erosion despite compaction from trampling; bare soil provides new habitat for invading species; and loss of soil and nutrients alters water quality. Changes in vegetation cover, and the sights, sounds, and smells of humans, adversely affect wildlife species (Ream 1980). Sensitive indicator elements in this interconnected dispersed recreation ecosystem that require our attention include water quality, fish, vegetation, soil, and wildlife (fig. 1).

A six step process of monitoring and evaluation has been proposed using the above ecosystem elements (Saunders 1985):

1. Identify key ecosystem elements in each proposed or existing wilderness area.
2. Select means of measurement for each element which best describes change.
3. Establish baseline data on each element.
4. Monitor elements at regular periodic intervals.
5. Develop standards and guidelines for assessing the impacts of management and use on key elements.
6. Adjust management practices and use levels in accordance with findings and planned goals and objectives.

Thus, wilderness management, in part, becomes selection of the best techniques of user and resource manipulation, guided by a systematic monitoring and assessment process to achieve planning goals and objectives.

The Inland Empire extends from the east side of the Cascade Crest in Washington, through northern Idaho, into western Montana, and south into

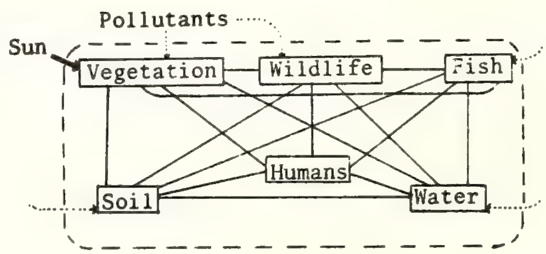

Figure 1.--Principal elements and their interrelationships in the wildland or dispersed recreation ecosystem.

Paper presented at the National Wilderness Research Conference, Fort Collins, CO, July 23-26, 1985.

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Oregon. Under provision of the 1964 Wilderness Act, several wilderness areas were established in the Inland Empire. Subsequent implementation of this act by the United States Department of Agriculture, Forest Service (USFS) Roadless Area Review and Evaluation (RARE I and RARE II) identified potential wilderness study areas.

Considerable dispersed recreation occurs in designated wilderness, with less in most RARE II areas. Wilderness designation may increase use in some of these areas. Therefore, long-term analysis of use and resource or ecosystem condition permits a before-and-after analysis not available in most existing wilderness areas. This long-term analysis is akin to monitoring. Our overall research goal is to characterize use and ecosystem condition in proposed wilderness areas. This characterization requires a monitoring program. The purpose of this paper is to critique our techniques based on preliminary results of monitoring research in proposed wilderness in the Inland Empire. In essence, we are identifying some key ecosystem elements and are reporting results of our implementation of a monitoring program. In the discussion which follows we offer managers recommendations for their monitoring programs, based on our results.

METHODOLOGY

Because of the diversity of wilderness ecosystems in the Inland Empire, our study is limited to subalpine cirque basins containing glacial lakes. Vegetation may be divided into forest and meadow. Forests are dominated by Abies lasiocarpa and Tsuga mertensiana with a variety of understory dominates including Xerophyllum tenax, Vaccinium scoparium, Luzula hitchcockii, or Boykinia major. Meadows are dominated by Carex nigra and other Carex species, as well as Spiraea densiflora, Phyllodoce empetriformis, Luetkea pectinata, and Gentiana calycosa. Elevation of the cirque basins ranges from 1575 to over 1900 meters; surrounding peaks may rise to over 2500 meters. Basins generally face north, northeast, or northwest. Lakes have surface areas of less than 1 to 5 hectares; depths range to 10 meters. Precipitation is primarily snow from October to July; frosts may occur any month.

Principal recreation activities include backpacking, horsepacking, fishing, hunting, and photography. Use centers around the lake in as many as five or six campsites, depending upon topography and bedrock outcropping. Campsites occur in forest and meadow, with and without horse use; some campsites receive more use than others. The few lakes without campsites are usually vernal, or surrounded by wet meadows, or hemmed in by steep cirque headwalls. Vegetation and soil sampling was done in these campsites and in nearby undisturbed control habitats. Water sampling was done in the cirque basin lakes.

Vegetation Sampling

Each campsite was mapped and sampled from the central fire ring using a series of transects which extended beyond the campsite into the surrounding forest or meadow (Cole 1982). Campsites were also photographed from the transects. Four transects were used for sampling vegetation and soils. Daubenmire 2 x 5 decimeter quadrats and cover classes (Daubenmire and Daubenmire 1968) were used to record vegetation, litter, rock, root, and bare soil cover at 1-m intervals along the four sampling transects. Species, location, diameter at breast height (dbh) if greater than 1 cm, and general condition were noted for all trees on or around campsites. Some trees were cored to determine age and growth rates. Overhead canopy density was measured from the fire ring using a spherical densiometer (Lemmon 1956, 1957).

Soil Sampling

Along the above mapping and sampling transects, slope, trails intersected, trees intersected, rock outcrops, and other notable features were recorded. Soil penetration resistance was measured at random distances within 2 m of the central campsite core along each sampling transect using a pocket penetrometer. A soil profile core to a depth of 36 cm was collected at each soil sample site. A quantity of soil was also collected for analysis. Laboratory analysis included pH, phosphorus, potassium, ammonia, nitrate, and texture.

Water Sampling

A baseline limnological study was part of the ecological profile developed for each lake basin. A bathometric map was produced and sampling station located at shallow and maximum depth sites at each lake. Standard physical and chemical limnological measurements were made at three levels in the water column (top, mid-column, and bottom) and three times during the use season (ice-off, mid-season, and late-season). These measurements included temperature, transparency (Secchi disk), hardness, alkalinity, pH, nitrates, phosphates, and primary productivity (carbon 14 light/dark bottle method).

One goal is to determine if there are physical and hydrochemical changes in these lakes over time and to relate these changes, if any, to recreational use. Our discussion on water quality monitoring in this paper will focus on the feasibility of using hydrochemical variables as indicators of recreational use. These indicators might be utilized in a limits of acceptable change (LAC) approach to management and planning (Stankey and others 1985).

DISCUSSION

Vegetation

Mapping transects proves an effective means of determining campsite size and campsite bare area. Relocation of these transects is relatively easy, allowing future resampling and mapping. Vegetation cover using Daubenmire quadrats and

cover classes provides complete species inventory and cover. Cover class estimation is a reliable technique that is easily taught and learned. It is presumed that cover will lessen in more heavily used sites, and sensitive species may disappear from campsites due to trampling, grazing, changes in microclimate, or increased sunlight.

Tree dbh is not likely to change rapidly. Tree sampling provides permanent markers for campsite resampling, permits assessment of long-term human and horse damage on trees, and provides data on rates of tree loss at campsites. Within the short duration of this study (three years) several live trees have been cut by hunters for building camp structures and for firewood.

Canopy density provides clear distinction between forest and meadow campsites in the laboratory. In general, forest campsites with a denser canopy have less vegetation in the campsite. Forest campsites may be more severely impacted and slower to recover from use than meadow campsites.

After a campsite has been used several times, rapid changes occur during the campsite establishment period. A well-established campsite will change more slowly with continuous use. Initial rapid changes include vegetation cover reduction, species loss, soil compaction, and litter loss. These changes are easily measured by the techniques described above. The rapid changes may occur over one or several seasons, depending on use level and habitat type.

Continued campsite changes, those that would occur at existing sites, are more subtle and thus harder to measure. Reduced tree growth rate is one possibility, but this requires repeated increment coring that could leave a tree susceptible to insects or diseases. Changes in native and exotic species cover or campsite size require annual or less frequent measurements because changes will be small. Unless an area has an upsurge in use or visual evidence of more damage, remeasurements may only be necessary every two to five years. This type of multi-year monitoring cycle would allow wilderness managers to completely sample their areas on a regular basis.

Soil

Slope measurement found most campsites to be on slopes of less than 5 percent. Campsites ranged from 4.2 to 864.7 sq m, with bare soil occupying up to 100 percent of the campsite. Campsites were generally located near but not on main trails. Distances from the campsites to the lake ranged up to 100 m. Soil penetration resistances were generally high. Soil profiles showed distinct O, A, and B horizons. Soil textures were medium. Soil pH ranged from 4.5 to 6.6. All soil nutrients had low concentrations. Slight differences were found between nutrients at campsites and control sites.

Soil changes at a campsite occur rapidly in response to campsite establishment or increased use. These changes include increased soil bulk density, loss of the litter layer, and soil erosion (Helgath 1975; LaPage 1967; Lutz 1945). Changes with continued use are more subtle, less understood, and harder to measure. Lockaby and Dunn (1984) reported increases in pH, calcium, and phosphorus, but could offer no explanation for the increases. A better understanding of the effects of use on soil properties is required. Unfortunately, wilderness areas lack detailed, modern soil surveys. In fact, soils in most wilderness areas are unmapped and unclassified. Therefore, determining what physical and chemical parameters to monitor and at what time interval will be a hit-or-miss proposition until we better understand the local soils and their characteristics.

Water

No single hydrochemical variable will serve as a good indicator of recreational impact for all small mountain lakes. Lake processes have evolved to maintain ecosystem stability. Unless changes imposed through recreational use are of a magnitude which exceeds these buffering capacities, subtle changes in many physical and chemical variables will not adversely affect system stability. Hydrochemical adjustment (buffering) is not a dramatic change in any one variable, but is the subtle adjustment of all variables to changes from within as well as from the outside. Each lake ecosystem is unique and will respond to the same kind of impact imposed from the outside in slightly different ways. Understanding each lake through a baseline limnological study will provide the insight needed to select key hydrochemical variables as unique indicators of recreational use in that system. Each lake must be monitored and managed as a distinct ecosystem (Aukerman and Springer 1976; Baron 1983; Perrine and Mah 1979; Silverman and Erman 1979).

There are many lake studies that support this premise. Silverman and Erman (1979) found the absence of phosphate at certain times of the year to be the factor limiting biological production at one group of lakes in Kings Canyon National Park. At lakes in an adjacent basin they found the limiting nutrient to be nitrate. We have found at least one lake where a trace element, not nitrate or phosphate, is limiting biological production. Nitrates, phosphates, and trace elements can be added to a system through recreational use (Dickman and Dorais 1977). If maintenance of the existing trophic state was a management objective, then the hydrochemical variables selected for monitoring the recreational impacts of these lakes would be different.

Accuracy and the cost effectiveness of monitoring techniques are important considerations for managers (Stankey and others 1985). The highly oligotrophic state of most small high mountain lakes means a very low concentration of all chemical substances. Some tests are complex and must be conducted in the exacting conditions of a laboratory. Transportation of samples often requires temperature control and acid fixation.

Analysis of some preserved samples must still occur within 24 hours (American Public Health Association 1981).

There are two hydrochemical variables of small mountain lakes which can be monitored by managers. Both of these measurements can be made simply and accurately in the field with electronic meters.

The first of these variables is pH. Small mountain lakes with igneous rock in their watersheds generally have a minimal capacity to absorb an influx of additional acid (Kling and Grant 1984). These lakes are vulnerable to acid rain (Baron 1983; Turk and Adams 1983). Impacts from acid rain might be mistakenly attributed to recreational use. The effects of acid rain can be monitored by pH measurements. Most small mountain lakes in volcanic regions tend to be slightly acid (Silverman and Erman 1979; Baron 1983). Mountain lakes which we continually monitor have pH values that vary from 6.5 to 6.9 through the use season. These same lakes have total alkalinity values of less than 11 mg/l (as $CaCO_3$). Alkalinity is a measure of water's ability to absorb acid. Our alkalinity values are far below the value suggested by Turk and Adams (1983) for lake sensitivity to acid rain. Rains with a pH value as low as 4.4 have been reported for Yellowstone National Park (Spokesman-Review 1985). Small high mountain lakes are undergoing changes as a result of acid rain (Kling and Grant 1984). Aquatic insects common in the diets of trout begin to disappear from lake ecosystems at pH 5 (Hynes 1960). Acid rain is a major threat to small mountain lakes.

The second hydrochemical variable to monitor is specific conductance. Conductivity is a measure of water's capacity for conveying an electrical current and this is directly related to the concentration of the ions present (Wetzle 1975). Conductivity is a macro-indicator of productivity (Lind 1974). Once baseline conductivity values are established for a particular lake through the use season, deviations from these expected values would indicate changes that could be related to recreational use. Dickman and Dorais (1977) observed an abnormally high phosphorus loading at Dinks Lake, Quebec, which they attributed to the reduction of plant cover and subsequent erosion in the lake basin caused by increased visitation. Conductivity would not identify the specific change in the ions present; it would simply alert the manager that a gross change has occurred. Further analysis would be necessary to assess this change. Monitoring conductivity would not detect all hydrochemical changes which might be related to recreational use, but it would be a valuable indicator of several important ones.

SUMMARY

Baseline monitoring studies on vegetation, soils, and water have been started in proposed wilderness using techniques adaptable to wilderness managers. All methods can be conducted at the technician level, but soil and water analysis requires exacting conditions. Vegetation monitoring is better for describing changes that occur with establishment of new campsites or growth of existing campsites. Soil monitoring describes changes during site establishment, and has the potential to indicate further changes as a result of continuing use. Monitoring water pH and conductivity will indicate if changes are occurring in cirque basin dispersed recreation sites, but only detailed analysis can determine the nature of change and its tie to recreational use.

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REFERENCES

Alden, H. R. Systems for analyzing impacts of outdoor recreation programs on environmental quality. In: Foxx, P. O., ed. Outdoor Recreation and Environmental Quality. Fort Collins, CO; 1973: 159-173.

American Public Health Association. Standard methods for the examination of water and waste water, 15th edition. Washington, D.C.; American Public Health Association; 1981. 1134 p.

Aukerman, R.; Springer, W. Effects of recreation on water quality in wildlands. Eisenhower Consortium for Western Environmental Forestry Research, Bulletin 2. Fort Collins, CO: Department of Recreation Resources, College of Forestry and Natural Resources, Colorado State University; 1976. 25 p.

Baron, J. Comparative water chemistry of four lakes in Rocky Mountain National Park. Water Resources Bulletin. 19(6): 897-902; 1983.

Cole, D. N. Wilderness campsite impacts: effect of amount of use. Research Paper INT-284. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 34 p.

Cole, D. N.; Schreiner, E. G. S. Impacts of backcountry recreation: site management and rehabilitation--an annotated bibliography. General Technical Report INT-121. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 58 p.

Daubenmire, R. F.; Daubenmire, J. B. Forest vegetation of eastern Washington and northern Idaho. Technical Bulletin 60. Pullman, WA: Washington Agricultural Experiment Station; 1968. 109 p.

Dickman, M. and M. Dorais. The impact of human trampling on phosphorus loading to a small lake in Gatineau Park, Quebec, Canada. Journal of Environmental Management. 5(4): 335-344; 1977.

Helgath, S. F. Trail deterioration in the Selway-Bitterroot Wilderness. Research Note INT-193. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1975. 15 p.

Hynes, H. B. N. The biology of polluted waters. Liverpool, England: Liverpool University Press; 1960. 202 p.

Kling, G. W.; Grant, M. C. Acid precipitation in the Colorado front range: an overview with time predictions for significant effects. Arctic and Alpine Research. 16(3): 321-329; 1984.

LaPage, W. F. Some observations on campground trampling and ground cover response. Research Paper NE-68. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1967. 11 p.

Lemmon, P. E. A spherical densiometer for estimating forest overstory density. Forest Science. 2(4): 314-320; 1956.

Lemmon, P. E. A new instrument for measuring forest overstory density. Journal of Forestry. 55(9): 667-668; 1957.

Lind, O. T. Handbook of common methods in limnology. St. Louis, MO: The C. V. Mosby Company; 1974. 154 p.

Lockaby, B. G.; Dunn, B. A. Camping effects on selected soil and vegetative properties. Journal of Soil and Water Conservation. 39(3): 215-216; 1984.

Lutz, H. J. Soil conditions of picnic grounds in public forest parks. Journal of Forestry. 43(2): 121-127; 1945.

Odum, E. P. Fundamentals of ecology. 3d ed. Philadelphia, PA: Saunders Publishing Company; 1971. 574 p.

Perrine, R. L.; Mah, R. A. Water quality in mountain recreational areas. Water Resources Bulletin. 15(3): 612-627; 1979.

Ream, C. H. Impact of backcountry recreationists on wildlife: an annotated bibliography. General Technical Report INT-84. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 72 p.

Saunders, P. R. Trends in dispersed recreation on the wildland resource. In: Outdoor Recreation Trends Symposium II. Myrtle Beach, SC. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Region; [In press].

Silverman, G.; Erman, D. C. Alpine lakes in Kings Canyon National Park, California: baseline conditions and possible effects of visitor use. Journal of Environmental Management. 8(1): 73-87; 1979.

Stankey, G. H.; Cole, D. N.; Lucas, R. C.; Peterson, M. E.; Frissell, S. S. The limits of acceptable change (LAC) system for wilderness planning. General Technical Report INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

The Spokesman-Review. Researchers study effects of acid rain in Yellowstone. 1985 April 13; 22 (col. 1).

Turk, J. T.; Adams, D. B. Sensitivity to acidification of lakes in the Flat Tops Wilderness area, Colorado. Water Resources Bulletin. 19(3): 346-350; 1983.

Wetzel, R. G. Limnology. Philadelphia, PA: Saunders College Publishing Company; 1975. 743 p.

AQUATIC ECOLOGY AND MANAGEMENT OF WILDERNESS STREAMS IN THE GREAT SAND DUNES NATIONAL MONUMENT, COLORADO

Laurence D. Zuckerman and Eric P. Bergersen

ABSTRACT: Physical rather than biological actions dominate the structuring of the aquatic community in Medano Creek, a wilderness boundary stream on the Great Sand Dunes National Monument. Although the invertebrate fauna is typical of that in Rocky Mountain streams, the transport of large loads of sand and wide fluctuations in surface water discharge make Medano Creek unique. Wind-blown and water-transported sand immediately begins restoring the wilderness appearance of the dunes and stream bed when it is disturbed by visitors. Fishing pressure on introduced salmonids is light. Medano Creek is being considered as a restoration site for the native fish assemblage of Rio Grande sucker - Rio Grande chub - Rio Grande cutthroat trout. Conflicts in wilderness fish management on a national monument are discussed in light of these plans.

INTRODUCTION

Great Sand Dunes National Monument

The Great Sand Dunes National Monument in the San Luis Valley, Colorado, was established by a 1932 presidential proclamation to preserve the highest (in elevation above sea level) and tallest inland sand dunes in North America, and to preserve additional scenic, scientific, and educational features (Carter 1982; Hoffman 1975). The water resources of the monument play a large role in formation and movement of dune masses as well as in supporting a wide variety of aquatic life.

The Great Sand Dunes National Monument is located in Alamosa and Saguache Counties of the San Luis Valley. Annual precipitation averages 9.8 - 11.0 in. (25 - 28 cm), and air temperatures range from 50 - 93 F (-45.6 - 33.9 C) with annual mean, 43.6 F or 6.4 C (Colorado State Board of Immigration 1926; U.S. Bureau of Land Management 1977; U.S. Bureau of Reclamation 1970; U.S. National Park Service 1977). The monument contains the tallest and most spectacular dune mass in the United States; some dunes rise about 702 ft (214 m) above their base, which is at about 8,200 ft (2 500 m) elevation (Johnson 1971). For centuries the prevailing southwesterly winds have carried the sediments of the Rio Grande drainage across the San Luis Valley. Winds funnel through three low places in the tall Sangre de Cristos (Medano, Music, and Mosca Passes), lose velocity as they rise over the mountains and drop sand, though the lighter materials are carried over the mountains. Medano Creek acts as a barrier to the advancement of the dunes, cutting them back and carrying the sand farther downstream.

The three primary perennial streams flowing into the monument -- Medano, Mosca, and Sand Creeks (fig. 1) -- sink into the base sediment of the monument, flowing different distances above the surface depending on the water table, season, flow rates, and isolated thunderstorms that occasionally cause flash floods. The course of the water after it sinks underground is a matter of speculation; most probably it goes to Indian Springs, Big Spring Creek, and Little Spring Creek and eventually to the San Luis Lakes southwest of the monument.

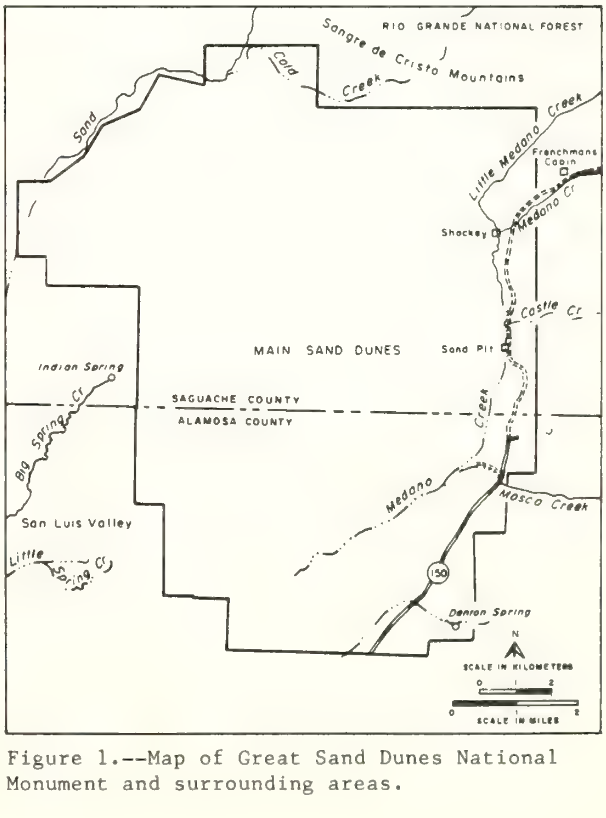

Figure 1.--Map of Great Sand Dunes National Monument and surrounding areas.

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A decreed water right allows Medano Creek to be diverted near Medano Pass to the Wet Mountain Valley in the Arkansas River drainage (Hoffman 1975). During dry years, this transbasin diversion adversely affects lower Medano Creek and its aquatic community. In 1976 these lower reaches of Medano Creek were placed within the designated Great Sand Dunes Wilderness Area. The middle portions of the creek act as the boundary between the designated wilderness and natural environment subzones on the monument. The Medano Pass Primitive Road crosses Medano Creek twice on Park Service land and the stream bed itself serves as the road for one section where the creek is the wilderness boundary. Little Medano Creek is entirely within the wilderness area. Upper Medano Creek and Medano Lake on the Rio Grande National Forest are on lands being considered for wilderness status by the U.S. Forest Service. The upper reaches of Sand and Cold Creeks are also being considered for inclusion in designated wilderness areas by the U.S. Forest Service and the U.S. Bureau of Land Management.

We sampled aquatic invertebrates, fish, water, and substrates of Medano Creek from a point upstream from Frenchman's Cabin on the Rio Grande National Forest to a point downstream from the main dune mass (in the spring and after heavy rains), and also surveyed Little Medano Creek, Mosca Creek, Denton Spring, Cold Creek (intermittent on the monument), Sand Creek, various unnamed spring seeps feeding into Sand Creek, and numerous temporary aquatic habitats.

The objectives of this study were to describe and contrast the aquatic communities of upper and lower Medano Creek on the Great Sand Dunes National Monument; to describe the unique qualities of the Medano Creek ecosystem and other aquatic resources of the monument; and to provide information that may be useful in making resource management decisions pertaining to the adverse effects of visitors on Medano Creek and to the reestablishment of native fishes.

PHYSICOCHEMICAL CHARACTERISTICS OF MONUMENT SURFACE WATERS

Water temperature, pH, dissolved oxygen, total alkalinity, nitrates, ammonia, sulfates, hardness, conductivity, flow rates, and depth were measured at all sampling sites, as were air and sand surface temperatures. Channel substrates were evaluated for size composition, predominant substrate type, and shape.

Concentrations of sulphates, ammonia, and tanins were below detection limits at all sites sampled. The pH of Indian Springs exceeded 8.5 -- far higher than the rest of the waters of the Great Sand Dunes National Monument, which are about pH 7.2. The differences between air, water, and sand temperatures are often large on Medano Creek, as demonstrated by measurements recorded on 15 July 1982 at the Castle Creek site: water temperature, 71 F (21.7 C); air temperature, 79 F (26.1 C); and sand surface temperature, 110 F (43.3 C). The flow pattern in Medano Creek is variable, consisting of pulses of water averaging 15 s between arrival time (Bean 1977). This pulsating flow results from continual dune formation and break-up in the sand bed of the stream, and a periodic release of the stored water. Visitors can hear these water surges when lower Medano Creek is flowing in late spring and after heavy summer thunderstorms.

The substrate in Medano Creek dominates the structuring of the aquatic community. Above the Castle Creek area, the stream has the usual components of the aquatic macroinvertebrate fauna of a Rocky Mountain cold headwater stream. The substrate there consists of gravel, sand, logs, detritus, rubble, and some boulders; gravel and rubble dominate in the riffle areas and detritus and silt occur in the depositional pools and beaver ponds. There are a few small areas of predominantly sand substrate, especially where the riparian zone is not well developed. Below Castle Creek, the substrate is almost entirely sand with some organic debris on the periphery. Few aquatic macroinvertebrates were collected here. The drift includes some organic matter but is mostly sand. Farther downstream, the creek becomes intermittent; rapid "retreat" of the leading edge of surface stream is very common in summer. The Castle Creek area defines a clear ecotone between the headwater stream and the lower relatively sterile, sandy intermittent creek.

BIOLOGY OF MONUMENT SURFACE WATERS

Aquatic Invertebrates

Composition.--Substrate cores of various diameters, a "meiofaunal pump" (Bou 1974), and large syringes were used to collect meiofauna from the interstitial community. We used Surber kicknets and dipnets to sample macroinvertebrates and drift nets to quantitatively sample macroinvertebrates and sources of organic matter such as twigs, branches, leaves, and decaying organisms.

A list of the macroinvertebrates was prepared on the basis of collections made in 1982 and 1983. For the macroinvertebrate communities sampled with Surber kicknets, we evaluated species diversity, using the Shannon Index (Lloyd and others 1968; MacArthur and MacArthur 1961); equitability or evenness (Lloyd and Ghelardi 1964; Pielou 1966, 1977); and species richness, using the Menhinick Diversity Index (Margalef 1957; Menhinick 1964). Macroinvertebrates were classified ecologically on the basis of habitat, trophic relationships, and habits (Merrit and Cummins 1978).

Many factors contribute to the problems of sampling the interstitial ecosystem of the Great Sand Dunes National Monument, mainly, however sampling equipment is needed that does not clog with sand. Many parameciums, rotifers, and smaller microorganisms were observed in one core sample of interstitial water from lower Medano Creek under a 30 X dissecting microscope on 19

July 1982; that day, the leading edge of the surface flow was "retreating" upstream rapidly -- about 26 ft (8 m) in 40 min.

Sampling of aquatic macroinvertebrates resulted in the collection of 75 forms of organisms divided among 40 identified families and 7 phyla -- Platyhelminthes, Rotifera, Nematoda, Nematomorpha, Mollusca, Annelida, and Arthropoda (table 1). A complete aquatic faunal list by site and date was prepared by Zuckerman (1984a). In the aquatic ecosystems of the Great Sand Dunes National Monument, the most important component in terms of number of individuals and species richness were aquatic insects, represented by 8 orders, 38 families, 57 genera, and 61 distinguishable forms.

When flows are insufficient to move sand, the lower reaches of Medano Creek are shallow, warm, and intermittent, and thus are not hospitable to aquatic macroinvertebrates. Drift nets set below the Shockey property (a private inholding) could not be set for more than 10 min. without the danger of the net being ripped or destroyed. Few aquatic invertebrates were associated with this moving sand. In drift nets set above Shockey's inholding in Medano Creek to a point upstream of the Frenchman's Cabin (fig. 1), we sampled numerous insects and twigs, branches, and leaves. Insects identified in drift samples above the monument-forest boundary of upper Medano Creek included four genera of mayflies; two genera of stoneflies; six dipterans (chironomids, black flies, crane flies, and rat-tail maggots); larval coleopterans of the Elmidae; one species of hemipteran; and one kind of caddisfly. Ostracods were also collected. At Shockey's inholding, below the road crossing, drift samples contained less organic debris and the following insects: two black fly genera and chironomids; two mayfly genera; two caddisfly genera; and one stonefly species.

The species diversity index was highest (2.194) in upper Medano Creek on the forest-monument border, where habitat diversity is greatest and flows are perennial. Often no macroinvertebrates were found in samples from lower Medano Creek. The most species (15) were found in upper Medano Creek above the Shockey inholding. Denton Springs, a small mineral spring pool had very few species -- mostly mosquito larvae and pupae -- whereas Indian Springs, a large spring emerging west of the main dune mass, had at least 15 different types of macroinvertebrates.

Visitor impacts.--Hundreds of visitors -- adults and children -- were observed in summer 1982 digging holes and building sand castles, "canals," and "dams" on lower Medano Creek, using their hands or toys, buckets, beer bottles, spoons, or even dirt shovels and post-hole diggers. These activities often created pools of standing water,

Table 1.--Summary of aquatic fauna collected in the Great Sand Dunes National Monument, 1982-1983

Phylum	Class	Orders	Number of families	Different genera	Taxa types
Platyhelminthes			Not further identified		
Rotifera			Not further identified		
Nematoda			Not further identified		
Nematomorpha		1	1	1	1
Mollusca		1	2	2	2
Annelida		2	2	3	3
	Oligochaeta	1	1	1	1
	Hirudinea	1	1	2	2
Arthropoda		12	42	61	66
	Arachnida	1	1	-	2
		Acarina	1	-	2
	Crustacea	3	3	3	3
	Ostracoda	1	1	1	1
	Copepoda	1	1	1	1
	Malacostraca	1	1	1	1
	Insecta	8	38	57	61
		Diptera	8	12	14
		Hemiptera	4	5	6
		Odonata	2	2	3
		Lepidotptera	1	1	1
		Ephemeroptera	4	6	6
		Trichoptera	7	9	9
		Plecoptera	4	4	4
		Coleoptera	8	18	18
Chordata		2	2	3	3
	Osteichthyes	2	2	3	3
		Salmoniformes	1	2	3
		Cypriniformes	1	1	1

sometimes as deep as 3.9 ft (1.2 m) which persisted for as long as 5 days, depending on their size, the direction and strength of the wind, their position in the creek bottom, and the flow of Medano Creek. The accumulation of organic debris carried by Medano Creek and wind-blown materials of terrestrial origin was followed by colonization by aquatic insects -- mainly hemipterans and coleopterans. Flying insects of both groups are capable of rapidly colonizing and abandoning temporary aquatic habitats. In experiments designed to enable us to estimate immigration rates and the effects of visitors on colonizing aquatic insects, we used screened plastic troughs as artificial pools in Medano Creek. Those troughs planted in the middle of the stream bed filled with sand most rapidly and were colonized by aquatic insects least often. Temporary pools on the periphery of Medano Creek collected organic detritus carried downstream in Medano Creek, but which remained wet throughout the 2-week study, were colonized faster than upstream troughs. Three genera of Coleoptera and one of Hemiptera were collected in the temporary pools along lower Medano Creek. Since there are no standing waters on the monument, we believe these insects originated from southwest of the Great Sand Dunes National Monument (Indian Springs and San Luis Lakes).

Visitor impacts on the aquatic systems of the Great Sand Dunes National Monument are varied. Creation of temporary pools provides a small amount of habitat for hemipterans and coleopterans that is not naturally common on the monument. Driving on the stream bed has little or no effect on the aquatic biota below Castle Creek; however, at the road crossings above Shockey's the continual destruction of the riparian zone by vehicles allows sand to settle and disrupt the biota. Fishing pressure on the monument is light. Upstream on the Rio Grande National Forest, trout are caught in Medano Creek and Medano Lake.

Fishes

We collected fish with backpack electroshocking equipment, minnow seines, and dip nets and made some observations from the banks of Medano and Sand Creeks. Microhabitat associations of the fishes, as well as the quality of the habitat, were noted. Fishes were classified ecologically on the basis of habitat, trophic relationships, and habits (Merritt and Cummins 1978). Fish are not stocked by the Colorado Division of Wildlife or the National Park Service on the monument.

Introduced species.--The brown trout (*Salmo trutta*) was first introduced from Europe to North America in 1883 (Luton 1985; MacCrimmon and Marshall 1968; Needham 1969) and to Colorado by 1885 (Wiltzius 1983). The "Frenchman," Ulysses Herard, who built a rearing pond near his cabin on Medano Creek, stocked the first brown trout in Medano Creek in the late 1890's. His original homestead is now contained in the Rio Grande National Forest and the dikes he built for his trout pond are still evident. Brown trout dominate the fish fauna of Medano Creek. Brook trout (*Salvelinus fontinalis*), first transplanted into Colorado in 1874 (Wiltzius 1983), have been reported on the monument. Brook trout were not collected by us or by the Colorado Division of Wildlife on the Great Sand Dunes National Monument, nor in samples taken from upper Medano Creek on the Rio Grande National Forest in 1982. However, brook trout were collected in 1983 above the monument-forest boundary by the Colorado Division of Wildlife (Nankervis 1984). Although we did not attempt to collect fish in Sand Creek, we observed brown trout and cutthroat trout (*Salmo clarki*) from the banks in a stream section within the Great Sand Dunes National Monument. The Colorado Division of Wildlife has stocked brown trout, brook trout, and cutthroat trout in Sand Creek upstream from the monument. Therefore, the cutthroat trout in Sand Creek are probably not native Rio Grande cutthroat trout (*Salmo clarki virginalis*) but rather "hybrid" Yellowstone cutthroat trout (*Salmo clarki bouvieri*) from Haypress Lake (Rio Grande drainage).

Juvenile brown trout were found lower in Medano Creek than previously believed. Young-of-the-year brown trout were observed and sampled near Castle Creek over sand substrate. These young trout probably do not survive well because of the lack of cover and food, and the widely fluctuating water temperature, flow, and depth. The common observation by the authors of belted kingfishers over the sandy stretches of lower Medano Creek might indicate their extreme vulnerability. Brown trout set up dominance hierarchies for feeding stations and instream cover with the less dominant fish moving downstream until available, suitable habitat is located (Raleigh and others 1984). These young-of-the-year brown trout may represent the surplus of yearly trout production in Medano Creek. Cover is plentiful in the form of riparian vegetation, pools, and instream structures (rocks, branches, and logs), preventing winterkill (Raleigh, and others 1984) in upper Medano Creek. However, like the creek itself, the pools and undercut banks are small and could not sustain a large population of large trout.

Native species.--No native fishes were captured on the Great Sand Dunes National Monument (table 2). Nearby in Indian Springs, formerly included within the monument's boundaries, is a large population of native fathead minnows (*Pimephales promelas*) which may have scientific and historic significance

Indian Springs contains a naturally reproducing population of fathead minnows, associated with algal-covered submerged tumbleweed in the springs. Some of these "brush piles" are up to 5 ft (1.5 m) high and cover much of the east shore of Indian Springs. According to Hubbs and Miller (1984), these fish may have great zoogeographical significance in that they are intermediate in meristic and morphological characters between the Rio Grande and Arkansas River subspecies of fathead minnow. The fathead minnows of Indian Springs also support a wide variety of piscivorous birds at the springs and in San Luis and Head Lakes

Table 2.--Fishes of the monument region: past and present

Common name	Scientific name	Origin	Status
Fathead minnow	Pimephales promelas	Native	Present
Rio Grande chub	Gila pandora	Native	Extirpated
Rio Grande sucker	Catostomus plebeius	Native	Extirpated
Rio Grande cutthroat trout	Salmo clarki virginalis	Native	Extirpated
Brown trout	Salmo trutta	Introduced	Present
Brook trout	Salvelinus fontinalis	Introduced	Present
Yellowstone cutthroat trout	Salmo clarki bouvieri	Introduced	Present

where the Indian Springs population acted as the "seed" for newly established fish populations. During wet years, Indian Springs flows to Head and San Luis Lakes, carrying fathead minnows and other aquatic organisms. The San Luis Lakes are now stabilized artificially as part of the San Luis Closed Basin Project (U.S. Bureau of Reclamation 1970) and the large populations of fathead minnows should continue to thrive (Zuckerman 1984b). Indian Springs and the other hydrological features of the Great Sand Dunes National Monument area are too geologically recent for unique fishes to have evolved in isolation from the Rio Grande drainage. This does not mean that the processes of genetic divergence are not operating, but rather that they have not reached the stage of taxonomic recognition.

The native fish assemblage of Rio Grande cutthroat trout, Rio Grande chub, and Rio Grande sucker was described by Jordan (1891) and probably remains only in a few waters in New Mexico. The endemic species group has been eliminated everywhere where it once occurred in Colorado's San Luis Valley due to fish introductions, overfishing, and habitat destruction (Zuckerman and Behnke 1985; Zuckerman and Langlois 1985).

Organic Matter Processing

Medano Creek serves an important role as a transportation system and processing site for organic materials created in the upland forests of the Great Sand Dunes National Monument and the Rio Grande National Forest, providing nutrients, organic matter, and sources of energy to the dune ecosystem. Unlike most headwater streams in the Rocky Mountains that are subsystems of much larger drainage basins in the river continuum (Cummins 1979), Medano, Mosca and Sand Creeks are intermittent streams that sink into the deep sand of the Great Sand Dunes. By sinking into the sand, debris in the form of coarse and fine particulate organic matter (OM) is deposited on the sand surface, where it is subject to the constant winds typical of the area. Instead of the continual processing of the allochthonous materials in most aquatic ecosystems, the particulate OM is returned much more rapidly to the terrestrial system, in a less degraded form. The fate of dissolved OM and nutrients that filter into the sand with the sinking water is not known but they may be used in part by dune vegetation, such as sunflowers and scurf peas, found along the lower reaches of the streams.

The different food resources of the headwater stream are used by different functional groups of macroinvertebrates and fishes. Both shredders and collectors act on the detritus, the shredders concentrating on processing the coarse particulate matter and collectors feeding on the fine and ultrafine particulate organic matter. Dissolved OM which has its sources from upstream leaching of particulate OM, ground water, and producer and consumer waste products, is less than 0.5 μm in diameter. No group of macroinvertebrates directly uses the dissolved OM in the processing system. The aquatic biota of the Great Sand Dunes National Monument were classified by functional feeding groups as well as their general habitat and habits after Merritt and Cummins (1978) and a complete list is available (Zuckerman 1984a). Mayflies are predominantly gathering collectors feeding on fine particulate OM in the sediments or scrapers; stoneflies are either shredders of coarse particulate OM or predators; crane flies (Tipulidae) are shredders, gathering collectors, or predators; and black fly and mosquitoe larvae are filtering collectors removing fine particulate OM from transport. Caddisflies are diverse in their functional feeding habits and are well represented in all groups (Wiggins 1977). The beetles are generally carnivorous piercers, some larval forms act as gathering collectors, chewing shredders, and scrapers. Nearly all of the hemipterans are carnivorous piercers. The Rio Grande chub and salmonids are generally engulfers of macro-invertebrates (carnivores) while large trout are piscivorous. The native Rio Grande sucker is a periphyton scraper (Zuckerman 1984b).

The sand substrate and water play a role in the processing of the coarse particulate and dissolved OM by mechanically grinding the leaves, needles, twigs, logs, and branches and filtering the dissolved OM before the creek enters the groundwater.

FISHERY MANAGEMENT CONSIDERATIONS

Reintroduction of Native Fishes

Medano Creek presents an excellent opportunity for the eradication of non-native fishes (brown trout and brook trout) and the reintroduction of the native fish fauna (table 2). Factors favorable for Rio Grande cutthroat trout production include gentle gradients, public lands (U.S. National Park Service and Rio Grande National Forest), few tributaries (Little Medano Creek), a lake at the headwaters (Medano Lake), natural barriers

downstream (sand; intermittent flows; and Closed Basin), few beaver dams, light fishing pressure, plentiful food, historic site (Jordan 1891), good water quality, good spawning habitat as indicated in extensive natural reproduction by brown trout, no conflicts with livestock management, minimal conflicts with water users, and the National Park Service's commitment to the reintroduction and maintenance of native species in natural areas in the Rocky Mountain Region. The Rio Grande cutthroat trout has been the subject of an extensive recovery program by the Colorado Division of Wildlife's Southwest Region and was, until recently, classified by the state as threatened and now is being considered in the "of special concern" category. Several progress reports (Gilbert 1985; Harrison 1983; Josselyn 1982; Langlois and Zuckerman 1981; Nankervis 1984; Zuckerman 1984b; Zuckerman and Langlois 1980) summarized yearly stream and lake surveys and the status of known populations. A novel approach could include reintroducing the native fish assemblage and not just the Rio Grande cutthroat trout (Zuckerman 1983; Zuckerman and Langlois 1985). Providing the original trophic structure of algivore - piscivore - insectivore may result in a more natural aquatic community and better production of Rio Grande cutthroat trout. In San Luis and Saguache Creeks (San Luis Closed Basin) and McIntyre Springs (Conejos River drainage), Rio Grande chub and Rio Grande sucker serve as a preferred forage for large brown trout (Zuckerman 1984; Zuckerman and Behnke 1985; Zuckerman and Langlois 1985). The complete assemblage might also be more resistant to future introductions of non-native fishes.

For successful reintroduction of the endemic fish fauna into Medano Creek, the brown trout and brook trout must be eliminated completely (Behnke and Benson 1980; Behnke and Zarn 1976). Chemical reclamation with a fish toxicant (Rosenlund 1984), would need to be repeated twice; once during low water conditions in the late summer-early fall before the non-native trout spawn and later before spring-runoff after any young trout parr emerge from the gravel redds. Although many invertebrates will also be killed with the fish toxicants, these typical Rocky Mountain stream insects are expected to rapidly repopulate Medano Creek from neighboring streams. Electrofishing surveys after reclamation could be used to verify total fish eradication, before any reintroductions are attempted. Potential sources for Rio Grande cutthroat trout are Trichera Creek on the Forbes Trinchera Ranch and the Lake Fork of the Conejos. Rio Grande chub from San Luis Creek of the San Luis Closed Basin could be transferred to Medano Creek. The Rio Grande sucker is proposed for listing by the Colorado Division of Wildlife as a "special concern" species (Zuckerman and Langlois 1985). The only two populations of Rio Grande sucker located in Colorado are genetically suspect because of widespread hybridization with the non-native white sucker, Catostomus commersoni (Zuckerman and Langlois 1985). Sources of pure Rio Grande sucker are available from New Mexico.

On 10-12 September 1985, the first stage of this reclamation plan was completed. Sixty gallons of liquid rotenone were applied to the Medano Creek drainage over an eight hour period by Colorado Division of Wildlife, U.S. National Park Service, U.S. Forest Service, and U.S. Bureau of Land Management personnel. Potassium permanganate was applied on a downstream section of Medano Creek to detoxify the active rotenone.

Fishing Regulations

Once established, special fishing regulations and a ban on fish stocking would have to be implemented on the entire Medano creek drainage, calling for cooperation between the National Park Service, Forest Service, Colorado Division of Wildlife, and the public. Cutthroat trout are ideally suited to special-regulations management because of their relatively long life span, low to moderate average natural mortality rates, good average growth (3-4 in./yr), and their vulnerability to angling exploitation to the extent that light fishing pressure (5-10 hours per acre per year) can remove more than 50% of all catchable-sized fish (Behnke 1978; Behnke 1986; Behnke and Benson 1980). In contrast, brook trout are short lived and slow growing in many Rocky Mountain streams and brown trout are the most difficult of the salmonids for anglers to harvest (Behnke and Benson 1980). Without catch-and-release or other special fishing regulations, the reintroduced cutthroat trout could be devastated by fishermen. Enforcement of fishery regulations would be the responsibility of the Great Sand Dunes National Monument and the Colorado Division of Wildlife, as are special hunting regulations in the monument area.

National Park Service Policies

Although obvious problems would accompany the reintroduction of native fishes on the Great Sand Dunes National Monument, the National Park Service has set precedents with its recent policies of preserving native fishes in Yellowstone National Park, Rocky Mountain National Park, Death Valley National Monument, Olympic National Park, and Great Smoky Mountains National Park (Behnke and Benson 1980; Behnke and Zarn 1976; Deacon and others 1979; Dean 1977; Houston and Contor 1984; Miller 1961; Minckley and Deacon 1968; Moore and others 1983; Pierce 1984; Rosenlund 1984; Varley 1984; Varley and Schullery 1983). The recent successes of native Western cutthroat trout subspecies as managed sportfish have largely been attributed to the use of special fishery regulations in Yellowstone and Rocky Mountain National Parks (Anderson 1979; Behnke and Benson 1980; Dean 1977; Varley 1984; Varley and Schullery 1983). Restrictive fishing regulations, however, can provide for much recreation while still protecting the resource. In the Yellowstone River in Yellowstone National Park, individual cutthroat trout are recycled by fishermen an average 10 times per fishing season; at the same time, populations are reaching historic levels for the first time after many years of overfishing (Anderson 1979; Varley 1984; Varley and Schullery

1983). Stocking of non-native and cultured fishes, which had occurred in the past on National Park lands, has been banned in the wilderness lakes of California's Yosemite, Kings Canyon, and Sequoia National Parks (Cordone 1977; Pister 1977; Wallis 1977), Yellowstone National Park (Varley 1984; Varley and Schullery 1983), Olympic National Park (Houston and Contor 1984), and Rocky Mountain National Park (Behnke and Benson 1980).

Complicating the preservation of native fauna on Park Service lands is the elimination of other "wild" trouts and the methods used. There is a semantic problem in the trout fishery management literature concerning "wild" versus "native" trout. Recently much esthetic and economic value has been placed on "wild" trout fisheries by state fishery agencies, fishery researchers, and trout fishing enthusiasts. Wild trout populations are naturally reproducing populations that do not depend on hatchery plants and can include natives as well as non-natives. "Native" fishes are those that historically occurred in a specific geographical area and were not originally introduced by man (Behnke 1978). Medano Creek currently contains a non-native, wild trout fishery. The questions most often asked by the public are, "Why do we have to kill some kinds of trout to restore others?" and "What makes the Rio Grande cutthroat trout (the native subspecies) better than the brook trout or brown trout?" Western native fishes need help for restoration because they evolved in geographical isolation from many predators and competitors, unlike the exotic brown trout, which man has fished and managed for thousands of years, and the transplanted brook trout, which evolved in richer biotic systems. These are sometimes difficult questions but nowhere are they easier to answer than on a national park or monument. The National Park Service Act of 1916 was enacted to conserve "scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of future generations." Despite the well-meaning intentions of the original act there was little enforcement, so that early fishery programs greatly altered and modified the original aquatic environments and the endemic aquatic life forms (Wallis 1977). To restore to a natural condition and perpetuate at least a portion of the native fauna in the National Park System, the National Park Service adopted a general resources management policy in 1975. The 1975 fishery management policy provides that, in national parks, "No artificial stocking of fish species exotic to a park will occur; artificial stocking of fish may only be employed to reestablish native species. Naturally barren waters will not be stocked with either native or exotic fish species." With the Congressional intent to allow fishing in National Parks dating back to the establishment of Yellowstone, the Park Service will continue this practice but reserved the right to ban fishing to protect rare, threatened, or endangered plant and animal species in the waters or in adjacent habitat; or when the fishery resource has greater value to greater numbers of visitors for nonconsumptive uses (i.e., esthetics, scientific study, interpretation, or environmental education); to protect spawning grounds of endemic fishes; and to maintain natural distributions or densities of native wildlife species that use fish for food, such as the grizzly bear, bald eagle, and pelican (Wallis 1977). The National Park Service fishery policy allows for different regulations for native and non-native species and for modifications for specific waters.

Wilderness Area Management

Not only is Medano Creek in a national monument, but portions of it are in a designated wilderness area. Other sections are in a natural zone or act as the boundary between the wilderness area and the natural zone. National Park Service policy for fishery management in natural zones "shall be specifically aimed towards preservation and/or restoration of native species...and shall be regulated for native species so that mortality from fishing is compensated by natural reproduction and that fishing mortality does not cause significant alterations from the historical (unexploited) density and age structure of the population." Examples of other fish restoration projects in wilderness areas are in the literature but most are on national forests or in the case of the high Sierra lakes of California's National Parks, waters that were naturally barren of fishes. The current Forest Service policy relies on the language and intent of the Wilderness Act of 1964 as interpreted and effectuated by Secretary of Agriculture Regulations and Directives of the Chief of the Forest Service (Hall 1977). The emphasis is on naturalness and natural process, with little interference by, or evidence of, man and his works. The decline and recovery of the Gila trout (Salmo gilae) in the Gila and Aldo Leopold Wilderness Areas of the Gila National Forest is a prime case study (Behnke 1985). Wilderness designation of the Gila trout habitat carries a double edge; it protects the watersheds from the potential abuse of multiple-use management of streams on public lands but hinders restoration projects by prohibiting the use of vehicles, helicopters, chain saws, and other mechanized equipment. In the Great Smokey National Park, the Park Service took this prohibition one step further and did not allow the use of chemicals to eliminate introduced rainbow trout (Salmo gairdneri) resulting in the unsuccessful restoration of native brook trout (Larson and Moore 1985; Moore and others 1983).

Leopold (1975) stressed the need to use streams on wilderness areas in national parks for comparative studies with streams in multiple use areas so that the effects of multiple use management on aquatic ecosystems could be examined. "Gene banks" have been established in North America and the USSR to preserve wild sources of seed used in agriculture. As in animal husbandry and the development of food crops, an analogous situation exists between wild stocks of fish and hatchery fish and stocking practices. Helle (1984) has called for the designation of watersheds as gene banks, where hatcheries and stocking are not allowed and the

wild stocks of fish would be subjected only to natural selection. He recommends watersheds within national parks, since the National Park Service has goals that are consistent with the idea of preserving the integrity of stocks of native fishes. Native fishes have intangible values that cannot be easily estimated in cost-benefit analyses (Pister 1976). Included are diverse recreational benefits that result from wider distributions of native fish populations in time and space; the future benefit of a diverse reservoir of genetic variation; aesthetic and cultural qualities; and bet-hedging against disasters (Martin 1984). The presence of wild animal populations increases the aesthetic and wilderness value of an aquatic ecosystem. Nonconsumptive uses of fish by visitors, besides catch-and-release fishing, have turned into a major recreational use of the resource in Yellowstone National Park. Fishing Bridge was closed originally to fishing to protect trout spawning runs, but 130,000 people watched fish from it in 1978 (Varley and Schullery 1983). In back-country user surveys in California, nearly half of the persons surveyed had no interest in fishing and 20% expressed disapproval of fishery management in wilderness areas (Carpenter and Boulus 1975; Nicola 1977; Pister 1977). In the management of Forest Service wilderness areas, the concept of wilderness as the resource value being protected and managed is important (Hall 1977). Angling is viewed as simply one of the subsidiary resources and values. Native species and management consistent with maintenance of wilderness values are basic concepts. Perhaps Charles Adams (1925) summed it up best with his statement, "the idea that forests with big game animals should be maintained as a wilderness, and that there is an advantage in natural wild waters, appears to be a new conception for our parks. Some of the same persons who are very eager to maintain a wilderness for certain purposes have never recognized that others are equally interested in an untouched aquatic wilderness."

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REFERENCES

Adams, Charles C. The relation of wild life to the public in National and State parks. Roosevelt Wild Life Bulletin. 2(4): 371-402; 1925.

Anderson, Jack A. The Yellowstone Park experience with catch-and-release fishing. In: Barnhart, Roger A.; Roelofs, Terry D., eds. Catch-and-release fishing as a management tool: A national sport fishing symposium: Proceedings; 1977 September 7-8; Arcata, CA. Arcata, CA: Humboldt State University; 1979; 7-9.

Bean, Daniel William. Pulsating flow in alluvial channels. Fort Collins, CO: Colorado State University; 1977. 124 p. M.S. thesis.

Behnke, Robert J. Use of native trout in special regulations fisheries. In: Hashagen, Kenneth, ed. Proceedings of a national symposium on wild trout management; 1977 February 3; San Jose, CA. San Francisco, CA: California Trout, Incorporated; 1978; 45-47.

Behnke, Robert J. Gila trout. Trout. 26(3); 1985. [in press].

Behnke, Robert J. Yellowstone cutthroat trout, Salmo clarki bouvieri. Trout. 27; 1986. [in press].

Behnke, Robert J. Personal communication. Fort Collins, CO: Colorado State University, Department of Fishery and Wildlife Biology; 1985.

Behnke, Robert J.; Benson, Del E. Endangered and threatened fishes of the upper Colorado River Basin. Bulletin 503A. Fort Collins, CO: Colorado State University, Cooperative Extension Service; 1980. 34 p.

Behnke, Robert J.; Zarn, Mark. Biology and management of threatened and endangered western trouts. General Technical Report RM-28. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1976. 45 p.

Bou, Claude. Recherches sur les eaux souterraines -25- Les methodes de recolte dans les eaux sauterraines interstitielles. (Research on subterranean waters -25- Sampling methods for underground interstitial waters). Annales de Speleologie. 29(4): 611-619; 1974.

Carpenter, M. Ralph; Boulus, Donald R. Attitudes toward fishing and fisheries management of users in Desolation Wilderness, California. California Fish and Game. 62(3): 168-178; 1976.

Carter, C. Joe. Great Sand Dunes National Monument: An administrative history. The San Luis Valley Historian. 14(2): 3-12; 1982.

Colorado State Board of Immigration. Colorado: The San Luis Valley. Denver, CO: Colorado State Board of Immigration; 1926. 24 p.

Cordone, Almo J. High mountain lake management in California; Views of the Department of Fish and Game. In: A symposium on the management of high mountain lakes in California's national parks: Proceedings of a symposium; 1976 January 29; Fresno, CA. San Francisco, CA: California Trout, Incorporated; 1977: 63-67.

Cummins, Kenneth W. The natural ecosystem. In: Ward, James V.; Stanford, Jack A., eds. The ecology of regulated streams. New York: Plenum Press; 1979: 7-24.

Deacon, James E. and others. Fishes of North America endangered, threatened, or of special concern: 1979. Fisheries. 4(2): 29-44; 1979.

Dean, Jack. The Yellowstone experience. In: A symposium on the management of high mountain lakes in California's national parks: Proceedings of a symposium; 1976 January 29; Fresno, CA. San Francisco, CA: California Trout, Incorporated; 1977: 35-38.

Gilbert, David. Rio Grande cutthroat trout management. Job Progress Report, Nongame Investigations, FW-23-R-1. Montrose, CO: Colorado Division of Wildlife; 1985. [in press].

Hall, A. E., Jr. Forest Service fishery management policy and practice at California NFS Wilderness Lakes, 1976. In: A symposium on the management of high mountain lakes in California's national parks: Proceedings of a symposium; 1976 January 29; Fresno, CA. San Francisco, CA: California Trout, Incorporated; 1977: 51-52.

Harrison, Philip. Rio Grande cutthroat trout management. Job Progress Report, Nongame Investigations, FW-26-P-1. Monte Vista, CO: Colorado Division of Wildlife; 1983. 48 p.

Helle, John H. "Gene banks" for wild fish stocks. In: Walton, J. M.; Houston, Douglas B., eds. Proceedings of the Olympic wild fish conference; 1983 March 23-25; Port Angeles, WA. Port Angeles, WA: Peninsula College; 1984: 41-44.

Hoffman, Dennis K. Statement for management; Great Sand Dunes National Monument. Mosca, CO: U.S. National Park Service; 1975. 17 p. + 6 app.

Houston, Douglas B.; Contor, Roger J. Anadromous fish in Olympic National Park: Status and management considerations. In: Walton, J. M.; Houston, Douglas B., eds. Proceedings of the Olympic wild fish conference; 1983 March 23-25; Port Angeles, WA. Port Angeles, WA: Peninsula College; 1984: 97-111.

Hubbs, Carl L.; Miller, Robert Rush. Correlation between fish distribution and hydrographic history in the desert basins of Western United States. In: The Great Basin with emphasis on glacial and postglacial times. Bulletin of the University of Utah. 38: 17-166.

Johnson, Ross B. The Great Sand Dunes of southern Colorado. In: James, H. L., ed. Guidebook of the San Luis Basin, Colorado. Albuquerque, NM: New Mexico Geological Society; 1971: 123-128.

Jordan, David Starr. Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined. Bulletin of the U.S. Fish Commission. 9(1889): 1-40, 5 pl.

Josselyn, Sheryl. Rio Grande cutthroat trout management. Job Progress Report, Nongame Investigations, FW-23-R-1. Monte Vista, CO: Colorado Division of Wildlife; 1982. 43 p.

Koster, William J. Guide to the fishes of New Mexico. Albuquerque, NM: University of New Mexico Press; 1957. 116 p.

Langlois, David; Zuckerman, Laurence D. Rio Grande cutthroat trout: Inventory, restoration, and monitoring. Performance Report, Nongame Investigations, FW-22-R-2. Montrose, CO: Colorado Division of Wildlife; 1981; 16 p.

Larson, Gary L.; Moore, Stephen E. Encroachment of exotic rainbow trout into stream populations of native brook trout in the Southern Appalachian Mountains. Transactions of the American Fisheries Society. 114(2): 195-203.

Leopold, A. Starker. Ecosystem deterioration under multiple use. In: Proceedings of the wild trout management symposium; 1974 September 25-26; West Yellowstone, MT. Denver, CO: Trout Unlimited, Incorporated; 1975: 96-98.

Lloyd, M.; Gherlardi, R. J. A table for calculating the equitability component of species diversity. Journal of Animal ecology. 33:217-225; 1964.

Lloyd, M.; Zar, J. H.; Karr, J. R. On the calculation of information theoretical measures of diversity. American Midland Naturalist. 79(2): 257-272; 1968.

Luton, John R. The first introductions of brown trout, Salmo trutta, in the United States. Fisheries. 10(1): 10-13; 1985.

MacArthur, R. H.; MacArthur, J. W. On bird species diversity. Ecology. 42: 594-598; 1961.

MacCrimmon, H. R.; Marshall, T. L. World distribution of brown trout, Salmo trutta. Journal of the Fisheries Research Board of Canada. 25: 2527-2548; 1968.

Margalef, R. Information theory in ecology. General Systematics. 3: 36-71; 1957.

Martin, James T. Social value of wild fish. In: Walton, J. M.; Houston, Douglas B., eds. Proceedings of the Olympic wild fish conference; 1983 March 23-25; Port Angeles, WA. Port Angeles, WA: Peninsula College; 1984; 297-301.

Menhinick, E. F. A comparison of some species - individuals diversity indices applied to a sample of field insects. Ecology. 45: 859-861; 1964.

Merritt, Richard W.; Cummins, Kenneth W., eds. An introduction to the aquatic insects of North America. Dubuque, IA: Kendall/Hunt Publishing Company; 1978. 441 p.

Miller, Robert Rush. Man and the changing fish fauna of the American Southwest. Michigan Academy of Science, Arts and Letters. 46: 365-404; 1961.

Minckley, William L.; Deacon, James E. Southwest fishes and the enigma of "endangered species." Science. 159(3822): 1424-1432.

Moore, Stephen E.; Ridley, Broomfield; Larson, Gary L. Standing crops of brook trout concurrent with removal of rainbow trout from selected streams in Great Smoky Mountains National Park. North American Journal of Fisheries Management. 3(1): 72-80; 1983.

Nankervis, Jim. Rio Grande cutthroat trout management. Job Progress Report, Nongame Investigations. Montrose, CO: Colorado Division of Wildlife; 1984.

Needham, Paul R. Trout streams. revised ed. New York: Winchester Press; 1969. 241 p.

Nicola, Stephen J. Trout research in high mountain lakes. In: A symposium on the management of high mountain lakes in California's national parks: Proceedings of a symposium; 1976 January 29; Fresno, CA. San Francisco, CA: California Trout, Incorporated; 1977: 21-26.

Pielou, E. C. Species diversity and pattern diversity in the study of ecological succession. Journal of Theoretical Biology. 10:370-383; 1966.

Pielou, E. C. Mathematical ecology. New York: John Wiley and Sons; 1977. 385 p.

Pierce, Bryan E. Current status of trouts endemic to Lake Crescent, Washington. In: Walton, J. M.; Houston, Douglas B., eds. Proceedings of the Olympic wild fish conference; 1983 March 23-25; Port Angeles, WA. Port Angeles, WA: Peninsula College; 1984: 69-77.

Pister, Edwin P. A rationale for the management of nongame fish and wildlife. Fisheries. 1(1): 11-14; 1976.

Pister, Edwin P. The management of High Sierra lakes. In: A symposium on the management of high mountain lakes in California's national parks: Proceedings of a symposium; 1976 January 29; Fresno, CA. San Francisco, CA: California Trout, Incorporated; 1977: 27-34.

Raleigh, Robert F.; Zuckerman, Laurence D.; Nelson, Patrick C. Habitat suitability index models and instream flow suitability curves: Brown trout. FWS/OBS-82/10.71. Washington, D.C.: U.S. Fish and Wildlife Service; 1984. 71 p.

Rosenlund, Bruce D. Use of antimycin in the restoration of the greenback cutthroat trout, Rocky Mountain National Park, Colorado. Proceedings of the 19th Annual Meeting of the Colorado-Wyoming Chapter of the American Fisheries Society; 1984 March 7-8; Fort Collins, CO. Fort Collins, CO: Colorado-Wyoming Chapter of the American Fisheries Society; 1984: 932. Abstract.

U.S. Bureau of Land Management. San Luis Resource Area grazing management. Draft Environmental Statement. Denver, CO: U.S. Bureau of Land Management; Colorado State Office; 1970.

U.S. Bureau of Reclamation. A report on Closed Basin Division, San Luis Valley Project, Colorado. House Document No. 91-369, 91st Congress, 2d session. Washington, D.C.: Government Printing Office; 1970. 162 p.

U.S. National Park Service. Great Sand Dunes. Washington, D.C.: Government Printing Office; 1977. 4 p.

Varley, John D. The use of restrictive regulations in managing wild salmonids in Yellowstone National Park with particular reference to cutthroat trout, Salmo clarki. In: Walton, J. M.; Houston, Douglas B., eds. Proceedings of the Olympic wild fish conference; 1983 March 23-25; Port Angeles, WA. Port Angeles, WA: Peninsula College; 1984: 145-156.

Varley, John D.; Schullery, Paul. Freshwater wilderness, Yellowstone fishes and their world. Yellowstone National Park; The Yellowstone Library and Museum Association; 1983. 132 p.

Wallis, Orthello L. Management of high-country lakes in the National Parks of California. In: A symposium on the management of high mountain lakes in California's national parks: Proceedings of a symposium; 1976 January 29; Fresno, CA. San Francisco, CA: California Trout, Incorporated; 1977: 53-61.

Wiggins, G. B. Larvae of the North American caddisfly genera (Trichoptera). Toronto, Ontario: University of Toronto Press; 1977. 401 p.

Wiltzius, William J. Historic fish cultural and stocking compendium for Colorado, 1872-1978. Fort Collins, CO: Colorado Division of Wildlife; 1983. 254 p. Unpublished draft.

Zuckerman, Laurence D. Rio Grande River fishes management. Progress Report, November 1982 to June 1983. Montrose, CO: Colorado Division of Wildlife; 1983. 53 p.

Zuckerman, Laurence D. Limnology of a seasonally intermittent stream perched on deep sand deposits in Great Sand Dunes National Monument. Fort Collins, CO: Colorado Cooperative Fishery Research Unit; 1984a. Contract No. CX1200-1-B019. 73 p.

Zuckerman, Laurence D. Rio Grande fishes management; July 1983 to June 1984. Fort Collins, CO: Colorado State University; Department of Fisheries and Wildlife Biology; 1984b; Annual report to the Colorado Division of Wildlife. 150 p.

Zuckerman, Laurence D.; Behnke, Robert J. Effects of introductions on the native fishes of the San Luis Valley. In: The role of fish culture in fishery management: Proceedings; 1985 March 31-April 3; Lake Ozark, MO. Bethesda, MD: American Fisheries Society. [in press].

Zuckerman, Laurence D.; Langlois, David. Rio Grande cutthroat trout restoration. Preliminary Report, Nongame Investigations, FW-22-R. Montrose, CO: Colorado Division of Wildlife; 1980. 7 p.

Zuckerman, Laurence D.; Langlois, David. Status of the Rio Grande sucker and Rio Grande chub in Colorado. Proceedings of the 20th Annual Meeting of the Colorado-Wyoming Chapter of the American Fisheries Society; 1985 March 20-21; Laramie, WY. Fort Collins, CO: Colorado-Wyoming Chapter of the American Fisheries Society. [in press].

DEVELOPMENT OF WATER QUALITY MONITORING STRATEGIES IN TWO UNITS OF THE NATIONAL PARK SERVICE

Mark Flora and Sam Kunkle

ABSTRACT: The design and implementation of water quality monitoring programs in two units of the National Park Service are presented. Monitoring strategies used in Big Thicket National Preserve (Texas) and Big South Fork National River and Recreation Area (Tennessee and Kentucky)--where water quality is degraded by oil and gas development, mining activities, watershed disturbance, and septic leakage and effluent discharge--are discussed relative to planning, implementation, and assessment activities. The resulting programs meet data needs while being both cost-effective and responsive to management concerns.

INTRODUCTION

In their review of water resource issues in areas managed by the National Park Service (NPS), Gardner and Dennis (1982) reported that the majority of the more than 300 areas surveyed expressed concern about water quality impacts resulting from identifiable activities occurring either inside the boundary or within the upstream watershed of the unit. Water quality problems frequently encountered resulted from activities that include the following:

- oil and gas development
- coal mining and abandoned mine seepage
- placer mining
- discharge of effluents from towns and recreation sites
- road construction, logging, and other watershed disturbances
- local agricultural practices
- acid precipitation
- ground-water contamination

While more than 160 NPS areas express concern about actual or potential water quality degradation, in 1985 fewer than twenty maintain an in-house staff specifically trained in areas relating to their water resource problems. Because of this, watershed and water quality specialists of the National Park Service Water Resources Division in Fort Collins, Colorado, have been cooperating closely with field resource management specialists in several NPS units to develop water quality monitoring strategies that are cost-effective and representative of the needs of park managers. Because a large number of areas experiencing problems have limited resources, our approach to program design has tended toward the analysis of site-specific activity rather than the establishment of a comprehensive baseline.

In this paper we will discuss the implementation of this approach in two National Park Service units where identifiable activities that adversely influence water quality are widespread and could become even more extensive in the future.

METHODOLOGY

Designing an effective water quality monitoring program requires careful planning. First, a sampling network must utilize proper siting and sampling frequency; and because of budgetary constraints, it must often be focused on those water quality parameters that are directly affected by specific activities within the area's watershed. The development and implementation of a water quality program that will meet present management requirements and provide necessary data related to present and future water quality planning includes the following steps:

- identification and preliminary assessment of existing or potential water quality impacts
- definition of precise management objectives in dealing with the specific water quality problem
- development of a monitoring design that adequately addresses management objectives and meets probable future data requirements
- evaluation and selection of the most cost-effective implementation strategy (i.e., in-house, cooperative agreement, contractor, etc.)
- training of necessary personnel
- establishment of an adequate quality assurance program
- design of a data management and analysis plan
- integration of monitoring results with management alternatives.

Experience has shown that inadequate attention to one or more of the above planning steps can lead

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to the expensive collection of large amounts of data which, when evaluated, fail to yield information appropriate in the assessment of critical water resource issues. It is difficult to overemphasize the need for having a well thought-out and specific monitoring plan prior to its implementation in the field.

The authors are developing monitoring strategies that focus on eight of the most frequently encountered water quality issues affecting National Park Service waters. In this paper we discuss the implementation of these strategies in Big Thicket National Preserve (Texas) and Big South Fork National River and Recreation Area (Tennessee and Kentucky).

Big Thicket National Preserve

Big Thicket National Preserve (BITH) is located in southeastern Texas in a zone of convergence that is the crossroads of five major biological communities (southeastern swamp, eastern forest, central plains, Appalachian, and southwestern desert). The preserve itself comprises 34,220 ha (84,550 acres) that are divided into twelve distinct management units, four of which are narrow corridor units along major rivers and streams. Because of its unusual configuration, the preserve has a long boundary (640 km or 400 mi) for its small size, creating additional difficulties in protecting the preserve's environment.

The water resources of BITH are diverse and include the lower reaches of the Neches River, several major stream systems, numerous smaller tributary streams, and extensive floodplain forest, baygall, and cypress sloughs. The majority of the watercourses within BITH have headwaters outside of the preserve. Predominant land-use activities in the upstream watershed that have the potential to degrade water quality include oil and gas development (both external and within the preserve); timber operations along the preserve's perimeter; the upstream discharge of sewage treatment effluents from small towns and developments; and increased housing and recreational development adjacent to the narrow river corridor units (Flora 1984). A summary of some of the more commonly occurring water resource problems associated with these activities is presented in table 1.

An evaluation of previous studies within the preserve (Flora and others 1985) indicates a number of water quality parameters that reflect upstream influences degrading water quality. These parameters include specific conductance, chlorides, total dissolved solids, and oil and grease resulting from oil and gas development; turbidity and total suspended solids reflecting timbering activities and watershed disturbance; and dissolved oxygen, fecal coliform bacteria, fecal streptococcus bacteria, and nutrient enrichment associated with sewage effluent and septic leakage. Additionally, discharge, pH, water temperature, and water color were determined to aid in the interpretation of data and the identification of impacted areas. Efforts have been made in previous water quality studies to coordinate water quality field surveys with periodic macroinvertebrate analyses conducted by a local university, and with other special intensive studies designed to assess the biological health of specific stream reaches.

Table 1.--A summary of commonly occurring water quality problems associated with land-use activities in the vicinity of Big Thicket National Preserve

Oil and gas development	• Direct oil spills from accidents, carelessness, or improper operation of equipment at wells, storage tanks, and pipelines, or during trucking operations.
	• Leakage, structural failure, or illegal discharge of produced water brines, drilling fluids, and cuttings from produced water impoundments.
	• Increased erosion resulting from poorly designed road, pad, and pipeline construction or from seismic lines.
	• Natural seeps of crude oil.
	• Contamination from herbicides used for brush control on rights-of-way.
Sewage effluent discharge	• Depressed dissolved oxygen concentrations and changes in algal, invertebrate, and fish community structure resulting from increased organic loading.
	• Localized toxicity resulting from discharge of highly chlorinated, treated sewage effluent.
	• Increased nutrient loading from treated sewage effluent.
Local timber operations	• Excessive runoff and nutrient loading from clearcut timbering.
	• Increased erosion from timbering activities and poorly designed logging roads.

Management objectives that include the maintenance of good water quality in unimpacted areas and the development of alternatives to improve water quality in presently degraded areas suggest a prioritization of monitoring activities. The surface waters of Big Thicket have been divided into three management and monitoring categories. Category 1 streams are those stream segments whose water quality is presently little impacted by upstream activities. These streams are accorded the highest protection priority, including the development of nondegradation standards. Category 2 waters are those stream segments already exhibiting degradation of one or more parameters due to either point or nonpoint sources. Management

strategies for these streams include monitoring to document and quantify the extent of existing water quality degradation and an activity inventory to identify point and nonpoint sources. Category 3 waters consist of those segments of major rivers and streams that flow through BITH and whose quality is regulated by the State of Texas Water Quality Standards (Texas Department of Water Resources 1984). Water quality monitoring in Category 3 is routinely conducted by the U.S. Geological Survey, whose data are used by the National Park Service in periodic assessments of Big Thicket's water quality.

Implementation alternatives for BITH's monitoring program range from the establishment of a small in-park laboratory to full contracting with the U.S. Geological Survey. An evaluation of the implementation alternatives indicates that the most cost-effective approach involves a combination of park staff activity and assistance from an independent laboratory. Specifically, qualified resource management specialists assigned to the preserve staff carry out field sampling and collect data on discharge, water temperature, specific conductance, pH, dissolved oxygen, and turbidity (table 2). The Trinity River Authority of Texas, a local river basin authority, maintains a fully staffed laboratory at Livingston, Texas, a distance of less than 50 km (31 mi) from most of the sampling sites. A cooperative agreement has been arranged whereby this laboratory will provide for the analysis of chlorides, total dissolved solids, total suspended solids, oil and grease, color, fecal coliform bacteria, and fecal steptococcus bacteria at a competitive cost.

Data analysis and the development of management alternatives will be conducted by the resource management staff of Big Thicket National Preserve, with technical assistance from the watershed management and water quality specialists of the National Park Service Water Resources Division.

In the case of Big Thicket National Preserve, it has been possible to establish a water quality program responsive to preserve needs at a cost of approximately $15,000 per year plus staff support. The presence of a larger-than-usual resource management staff and the high priority given to water resources in the preserve has led to a flexible and responsive program. Because field implementation and data management and interpretation are all accomplished at the field office level, the preserve staff is in a position to both integrate their results with resource management planning on a real time basis and to respond to emergency situations resulting from spills and other problems. Specialized guidance, evaluation, and quality assurance assistance available from regional and Washington support staff maximize the resources available.

Table 2.--Water quality monitoring parameters and implementation strategy in Big Thicket National Preserve, Texas

Field Measurements	In-Park Lab	Contract Lab
discharge (Q)	turbidity	chlorides
water temperature		total suspended solids
specific conductance		total dissolved solids
pH		oil and grease
dissolved oxygen		color
		fecal coliform bacteria
		fecal streptococcus bacteria

Big South Fork National River and Recreation Area

The Big South Fork National River and Recreation Area (BISO) encompasses approximately 49,750 ha (123,000 acres) of rugged gorge and adjacent plateau woodland in north-central Tennessee and southeastern Kentucky. The Big South Fork of the Cumberland River, which runs northward from Tennessee into Lake Cumberland, Kentucky, is the major water resource in this unit. Within the unit, the Big South Fork cuts a deep gorge through the Cumberland Plateau, forming walls from 80-125 m (260-400 ft) high. In addition, numerous streams of varying water quality enter BISO before emptying into the Big South Fork of the Cumberland River. When the National Park Service assumed management of the first sections of the area in the late 1970's, little was known of the water quality of the area. A 1982 reconnaissance study (O'Bara and others 1982) reported generally good water quality in western portions of the unit, while waters in the eastern and southern portions were moderately to severely degraded as a result of acidic drainage from abandoned coal mines, impacts from oil and gas activities, inflow from leaky septic systems and inadequately treated sewage, and erosion from watershed disturbances (table 3). In order to quantify the extent of the water quality degradation, the resource management staff implemented a water quality monitoring program in 1982.

More than 30 main-stem and tributary stations were monitored on a monthly basis from 1982-1985. The following parameters were monitored: water temperature, pH, specific conductance, alkalinity, acidity, hardness, iron, manganese, and sulfate (acid mine drainage); chlorides (oil and gas activity); total coliforms, fecal coliforms, fecal streptococci, and dissolved oxygen (domestic wastes); and turbidity (watershed disturbance). While the list of water quality parameters monitored (table 4) is not exhaustive, the selected parameters serve as good indicators of water quality degradation resulting from land-use activity within the drainage basin.

Because of the remote location of the recreation area, a staff hydrologist was hired in 1982 to establish a water quality laboratory and implement a water quality monitoring program. Program objectives included the establishment of water quality background data, the quantification and identification of trends in water quality degradation, and

the development of management alternatives for improving water quality.

An evaluation of the first two years of data from the monitoring indicates that the water resources of BISO can be categorized into five major water quality types ranging from undisturbed to severely polluted (Rikard and others, in preparation). With the identification of areal extent and the degree of water quality degradation documented, BISO management now has access to information important in both the identification of areas needing further research and in the formulation of management alternatives to help improve water quality.

CONCLUSIONS

While over 160 units of the National Park Service may be influenced by degraded water quality, almost 80 percent of the impacts result from eight specific activities. In a number of situations, adequate resources are not available to conduct detailed hydrological or limnological research efforts. In these cases, the implementation of activity-related strategies for water quality reconnaissance and

Table 3.--A summary of commonly occurring water quality problems associated with land-use activities near Big South Fork National River and Recreation Area

Activity	Potential Water Pollution Source
Coal mining and abandoned mines	• High specific conductance, low pH, and high heavy metal concentrations resulting from seeps from abandoned mine shafts and strip mines.
	• Elevated turbidity and sediment loading from erosion of strip mine areas and spoil piles.
	• Elevated turbidity and sediment loading from poorly designed mining roads.
Domestic sewage	• Bacterial contamination from inadequate and leaking septic systems.
Oil and gas development	• Direct oil spills and leaks from accidents, carelessness, or improper operation of equipment at wells, storage tanks, and pipelines, or during trucking operations.
	• Leakage, structural failure, or illegal discharge of produced water brines, drilling fluids, and cuttings from produced water impoundments.
	• Increased erosion resulting from poorly designed road, pad, and pipeline construction or from seismic lines.

Table 4.--Water quality monitoring parameters and implementation strategy in Big South Fork National River and Recreation Area

Field Measurements	In-park Lab	Contract Lab
water temperature	alkalinity	(none)
specific conductance	acidity	
pH	hardness	
dissolved oxygen	turbidity	
	chloride	
	iron	
	manganese	
	sulfates	
	total coliform bacteria	
	fecal coliform bacteria	
	fecal streptococcus bacteria	

monitoring has allowed units to develop programs focused on certain "red-flag" indicator parameters. The results of these monitoring efforts can then be used to develop management alternatives and to assess the need for more intensive studies. Further, the involvement of park resource management staff, as opposed to the contracting of entire programs to outside entities, has also been beneficial in integrating water quality planning into the operational resource management activities of the park unit.

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REFERENCES

Flora, Mark D. Development of a water quality monitoring program for Big Thicket National Preserve, TX. WRFSL Project Report No. 84-BITH-1. Fort Collins, CO: National Park Service Water Resources Field Support Laboratory; 1984. 29 p.

Flora, Mark D.; Lawrence, Stephen J.; and Cavendish, Mary G. A summary of water quality for the Big Sandy Creek Unit, Beech Creek Unit, and Turkey Creek Unit of Big Thicket National Preserve, Texas (1975-1981). Technical Report No. 85-BITH-1. Fort Collins, CO: National Park Service Water Resources Division; 1985. 61 p.

Gardner, George M.; Dennis, John. Water: A seriously threatened resource in the National Park system. In: Flug, Marshall, ed. Water management in park and recreation areas. WRFSL Report No. 82-5. Fort Collins, CO: National Park Service Water Resources Field Support Laboratory; 1982: 1-14.

O'Bara, C. J.; Pennington, W. L.; Bonner, W. P. A survey of water quality, benthic macroinvertebrates and fish for sixteen streams within the Big South Fork National River and Recreation Area. Final Report on Contract No. DACW62-81-C-0162. Cookeville, TN: Tennessee Cooperative Fishery Research Unit, Tennessee Technological University; 1982. 225 p.

Rikard, Michael; Kunkle, Sam; Wilson, Juliette. Big South Fork National River and Recreation Area: Water quality report. Fort Collins, CO: National Park Service Water Resources Division; [in preparation].

Texas Department of Water Resources. Texas surface water quality standards. Draft. Austin, TX; 1984. 116 p.

WATER CONTAMINATION WITH *GIARDIA* IN BACK-COUNTRY AREAS

Thomas J. Suk, John L. Riggs, and Bernard C. Nelson

ABSTRACT: Cysts of Giardia spp. were detected in 27 of 78 water samples collected at remote streams in California's Sierra Nevada range. The data suggest that intensity of human recreational use may play a significant role and/or be a useful indicator in the contamination of surface water with Giardia. Cysts of Giardia spp. were detected in 26 of 309 fecal samples collected from cattle grazing in back-country areas in the Sierra Nevada. The use of monoclonal antibodies allowed the detection of human-infective Giardia in cattle stools. Cysts of Giardia spp. were detected in 79 of 731 fecal samples collected from wild mammals throughout California. Since only 4 of the samples reacted with monoclonal antibodies, the role of wild mammals in the transmission of human giardiasis remains unclear.

INTRODUCTION

Intestinal parasites of the genus Giardia commonly infect humans and many other animals. Although the speciation of Giardia is still in question (Meyer and Jarroll 1980), G. lamblia is recognized as the most common pathogenic intestinal parasite in the United States, infecting an estimated 2 to 20 percent of the populace, depending on the community and age group studied (Centers for Disease Control 1977).

Infected persons often have no symptoms, although the disease (giardiasis) can cause illness ranging from severe enteropathy with malabsorption to chronic or self-limiting gastrointestinal disorders (Wolfe 1984). The reasons for this extreme variation in symptoms are not well understood.

Giardiasis can be transmitted through fecal contamination of food and water (Barnard and Jackson 1984; Craun 1984) or direct fecal-oral contact (Owen 1984). Although little data are available on the relative importance of these various modes of transmission, waterborne giardiasis has received the greatest attention due to the large numbers of people that can be affected by waterborne outbreaks. Since 1965, over 50 waterborne outbreaks (affecting more than 20,000 people) have been reported in the United States (Craun 1984).

Giardia has become a concern in wilderness areas because, in its cyst form, it can survive for months in cold water (Bingham and others 1979), and it is resistant to chemical disinfection (Jarroll and others 1981). Poor sanitation among back-country users could also be an important factor in the transmission of giardiasis.

Efforts have been underway since the mid 1970's to develop and improve methods to isolate waterborne cysts of Giardia (Jakubowski 1984). A portable apparatus has been developed by Sorenson and others (in preparation) which makes surveys in remote areas feasible. This method was used to obtain data on the role of humans in the contamination of back-country streams with Giardia.

Previous workers who detected cysts of Giardia spp. in cattle and wild mammals (Davies and Hibler 1979; Suk 1983; Wallis and others 1984) were not able to positively identify human-infective strains of G. lamblia. In this study, stool samples from cattle and wild mammals were tested for Giardia spp. and human-infective G. lamblia using newly developed immunofluorescence techniques (Riggs and others 1983; Riggs and others 1984).

METHODS

National park and national forest managers were asked to subjectively identify back-country stream sites which had the highest and lowest probability of human fecal contamination. (These sites are referred to as "high use" and "low use", respectively.) Factors considered in choosing sites included the total number of users in an area, the proximity of probable latrine sites to watercourses, and the surface drainage in areas of known human waste deposition. Most "high use" sites were located immediately downstream of popular wilderness campsites, but several were located at the mouths of watersheds experiencing heavy dispersed recreational use. After a "high use" site had been located, an attempt was made to locate a "low use" site of similar hydrology, geology, etc., either in an adjacent watershed or directly upstream of the

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"high use" site (above areas of concentrated use). The result is a system of paired sites in which the main variable is intensity of recreational use. A greater number of "high use" sites were sampled because suitable "low use" sites could not be located in all cases. No sites were located adjacent to or downstream of active grazing allotments. A total of 78 samples were collected from 69 sites.

The 69 sample sites ranged in elevation from 6,000 to 12,000 feet (1,830 to 3,660 meters), and were distributed over a distance of more than 200 miles (320 kilometers), from the Lake Tahoe basin in the north to Mount Whitney in the south. The exact location of all sample sites, the volume of stream water filtered, and the number of cysts detected in each sample are summarized in Suk and others (in preparation).

All sites were sampled during the summer of 1984 using the methods of Sorenson and others (in preparation). The apparatus was mounted on a backpack and transported to sample sites on foot. 100 gallons of stream water was filtered for most samples. However, less than 100 gallons was filtered for several samples where suspended materials caused premature clogging of the filters.

Stool samples were collected from cattle which graze on high-elevation summer allotments administered by the U.S. Forest Service. The allotments ranged in elevation from 6,000 to 10,000 feet (8,830 to 3,050 meters) and were distributed over a distance of more than 220 miles (350 kilometers), from the Lake Tahoe basin in the north to the Kern Plateau in the south. Samples were collected from 14 cattle herds on 5 national forests. The location of the allotments, the number of cattle sampled in each herd, and laboratory results are detailed in Suk and Riggs (in preparation).

Stool samples were collected while herds were corralled immediately prior to being released on summer allotments. Stool samples from only two herds were collected after the cattle were released to graze. Samples were collected from these two herds within 7 days after release. All samples were collected between May and July 1984.

About 5 grams of feces were collected off the ground from each animal. Only fresh (moist) stools were collected. Samples were placed in 2 percent formalin and transported to the laboratory for analysis. It was not always possible to collect stools from observed evacuations. Hence, there is a slight possibility that more than one sample may have been collected from the same animal. The age of the animal (cow or calf) was recorded for each sample. When defecation was not observed and the age of an animal could not be discerned from the appearance of the stool, the sample was labeled "unknown".

All cattle stools were initially screened for *Giardia* spp. using the methods of Riggs and others (1983). Stools found positive for *Giardia* spp. were tested for human-infective strains of *G. lamblia* using the methods presented by Riggs and others (1984).

Stool samples from wild mammals were obtained off the ground and with the use of live traps. Only fresh (moist) stools were collected. Samples were placed in 2 percent formalin and transported to the laboratory for analysis. Many samples were obtained in conjunction with endemic plague studies and were, therefore, collected in front-country areas (e.g. near campgrounds, picnic areas, etc.). A total of 731 samples were collected from 35 species of wild mammals from 1982 through 1984. Stool samples were tested for *Giardia* spp. using the methods of Riggs and others (1983). Samples collected in 1984 which were positive for *Giardia* spp. were tested for human-infective strains of *G. lamblia* using the methods presented by Riggs and others (1984). Samples collected prior to 1984 were not tested for human-infective *G. lamblia* because the methods were not yet available.

RESULTS AND DISCUSSION

Cysts of *Giardia* spp. were detected in 27 of 78 water samples collected from back-country streams. 44.9 percent (22 of 49) of the "high use" samples were positive for *Giardia* spp. (at least one cyst was detected), while only 17.2 percent (5 of 29) of the "low use" samples were positive.

The water samples were not tested for human-infective strains of *G. lamblia*. Therefore, the infectivity of the *Giardia* cysts and their source(s) remain unknown. However, these data suggest that the intensity of human use may play a significant role and/or be a useful indicator in the contamination of surface water with *Giardia*. Recreational back-country use(s) could contribute to water contamination with *Giardia* in several ways. Cysts of *Giardia* from human fecal matter can reach streams and lakes directly or via surface runoff (especially where body wastes are deposited where little soil or organic matter is present to inhibit overland runoff into surface channels). Even when fecal matter is buried in soil, some intestinal pathogens are not rapidly destroyed (Temple and others 1982). *Giardia* thus introduced by human carriers can be acquired and/or transmitted by insects and wild animals. Some wild animals, for example, will dig up and consume human waste which has been buried. This not only potentially establishes infection in the animal, but it can leave tissue paper on the surface to be blown into watercourses by the wind. Johnston (1978) reported seeing rodents "carrying and chewing on toilet paper and other waste." Humans also introduce dogs which can be vectors of giardiasis (Bemrick 1961; Davies and Hibler 1979). The higher incidence of *Giardia* in streams in "high use" areas may also be partially due to increased populations of rodents and other mammals made possible by anthropogenic food sources.

Giardia spp. was detected in 8.4 percent (26 of 309) of cattle tested (table 1), and in 85.7 percent (12 of 14) of herds tested. Human-infective G. lamblia was detected in 65.4 percent (17 of 26) of cattle positive for Giardia spp. Giardia spp. was detected in 5.9 percent (9 of 153) of cows, and 11.1 percent (15 of 135) of calves. Human-infective G. lamblia was detected in 2.6 percent (4 of 153) of cows, and 9.6 percent (13 of 135) of calves.

These figures probably underestimate the prevalence of Giardia in cattle, since only one stool sample was taken per animal, and it is known that infected animals often shed cysts intermittently (Wolfe 1984). No attempts were made to concentrate cysts from the stool samples, which decreases the chance of detection when few cysts are present. Unless cattle actually harbor more than one species of Giardia, this could explain why G. lamblia was only detected in 65.4 percent of those stools positive for Giardia spp. Another possibility is that there may be strains of G. lamblia in cattle which do not react with the monoclonal antibody developed by Riggs and others (1984).

The number of infected herds (12 of 14) was large given the small sample size (no more than 25 animals per herd). This indicates that Giardia is common among cattle herds in the Sierra Nevada.

Davies and Hibler (1979) reported that cattle were not positive for Giardia until mid to late summer and fall, and suggested that cattle may lose their Giardia infections during the winter and become reinfected the following summer. In this study, Giardia spp. and G. lamblia were detected in cows and calves in late spring and early summer, immediately prior to their release on high-elevation back-country allotments. Therefore, calves must be contracting Giardia while on their winter-season range.

Table 1.--Isolations of Giardia from cattle

herd	number tested	number pos. for Giardia spp.	number pos. for G. lamblia
1.	9	1	0
2.	25	3	1
3.	18	2	0
4.	24	2	2
5.	23	0	0
6.	24	2	2
7.	24	1	1
8.	24	2	2
9.	24	1	1
10.	24	2	2
11.	24	5	2
12.	24	0	0
13.	20	1	1
14.	22	4	3
TOTAL	309	26	17
COWS	153	9	4
CALVES	135	15	13
UNKNOWN	21	2	0

The most significant finding of this study is that cattle harbor human-infective Giardia. Cattle often defecate near or directly into water and also walk through feces enroute to water (Davies and Hibler 1979; Gary and others 1983). Cysts of Giardia from their stools may reach water by direct deposition or surface runoff. Thus, cattle should be considered significant vectors of waterborne giardiasis.

Giardia spp. was detected in 79 of 731 (10.8 percent) wild mammal stools collected between 1982 and 1984 (table 2), however, G. lamblia was only detected in 4 of 545 (0.7 percent) of those samples (Nelson and Riggs in preparation; Suk 1983). Animal species which were found positive for Giardia spp. are listed in table 3.

Table 2.--Isolations of Giardia from wild mammals

date collected	number collected	number pos. for Giardia spp.	number pos. for G. lamblia
pre-1984[1]	186	29	---
1984	545	50	4
TOTAL	731	79	---

[1]Samples collected prior to 1984 were not tested for G. lamblia

Table 3.--Wild mammals which tested positive for Giardia spp.

Canis latrans
Eutamias quadrimaculatus
Eutamias speciosus
Marmota flaviventris
Microtus californicus
Microtus longicaudus
Microtus montanus
Mustela erminea
Odocoileus hemionus
Peromyscus maniculatus
Spermophilus beecheyi
Spermophilus beldingi
Spermophilus lateralis

The four samples which were positive for G. lamblia were from rodents collected at four different front-country locations. Species which tested positive for G. lamblia were: Eutamias speciosus (1), Peromyscus maniculatus (1), and Spermophilus beecheyi (2).

It is difficult to draw firm conclusions on the role of wild mammals in the transmission of human giardiasis since only four samples tested positive for G. lamblia. Those samples which only tested positive for Giardia spp. may or may not have contained human-infective species/strains of Giardia.

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REFERENCES

Barnard, R.J., and G.J. Jackson. Giardia lamblia: the transfer of human infections by foods. In: Erlandsen, S.L., and E.A. Meyer, eds. Giardia and Giardiasis. New York, NY: Plenum Press; 1984:365-378.

Bemrick, W.J. A note on the incidence of three species of Giardia in Minnesota. J. Parasitol. 47:87-89; 1961.

Bingham, A.K., E.L. Jarroll, and E.A. Meyer. Giardia sp.: Physical factors of excystation in vitro and excystation vs. eosin exclusion as determinants of viability. Exp. Parasitol. 47:284-291; 1979.

Centers for Disease Control. Giardiasis--California, Colorado. Morbidity and Mortality Weekly Report. 26(7):60; 1977.

Craun, G.F. Waterborne outbreaks of giardiasis: current status. In: Erlandsen, S.L., and E.A. Meyer, eds. Giardia and Giardiasis. New York, NY: Plenum Press; 1984:243-261.

Davies, R.B., and C.P. Hibler. Animal reservoirs and cross-species transmission of Giardia. In: Jakubowski, W., and J.C. Hoff, eds. Waterborne Transmission of Giardiasis, Proceedings of a Symposium; 1978 September 18-20; Cincinnati, OH. Cincinnati, OH: U.S. Environmental Protection Agency (EPA-600/9-79-001); 1979:104-126.

Gary, H.L., S.R. Johnson, and S.L. Ponce. Cattle grazing impact on surface-water quality in a Colorado Front Range stream. J. Soil and Water Cons. 38(2):124-128; 1983.

Jakubowski, W. Detection of Giardia cysts in drinking water: state-of-the-art. In: Erlandsen, S.L., and E.A. Meyer, eds. Giardia and Giardiasis. New York, NY: Plenum Press; 1984:263-286.

Jarroll, E.L., A.K. Bingham, and E.A. Meyer. Effect of chlorine on Giardia lamblia cyst viability. Appl. Environ. Microbiol. 41(2):483-487; 1981.

Johnston, L. An investigation of animal hosts for Giardia lamblia in Bridger Wilderness Area. 1978. Unpublished paper on file at: U.S.D.A. Forest Service, Bridger-Teton National Forest, Jackson, WY.

Meyer, E.A., and E.L. Jarroll. Reviews and Commentary: Giardiasis. Am. J. Epidemiol. 3(1):1-12; 1980.

Nelson, B.C., and J.L. Riggs. Reservoirs of Giardia spp. in California. Berkeley, CA: California Department of Health Service; (in preparation).

Owen, R.L. Direct fecal-oral transmission of giardiasis. In: Erlandsen, S.L., and E.A. Meyer, eds. Giardia and Giardiasis. New York, NY: Plenum Press; 1984:329-339.

Riggs, J.L., K.W. Dupuis, K. Nakamura, and D.P. Spath. Detection of Giardia lamblia by immunofluorescence. Appl. Environ. Microbiol. 45(2):698-700; 1983.

Riggs, J.L., K. Nakamura, and J. Crook. Identifying Giardia lamblia by immunofluorescence. In: Pirbazari, M., and J.S. Devinny, eds. Environmental Engineering: Proceedings of 1984 Specialty Conference; NY. New York: American Society of Civil Engineers; 1984; 234-238.

Sorenson, S.K., J.L. Riggs, P.D. Dileanis, and T.J. Suk. Improved techniques for isolation and detection of Giardia cysts in water using large volume filters and direct immunofluorescence. Sacramento, CA: U.S.D.I. Geological Survey, Water Resources Division; (in preparation).

Suk, T.J. Investigation of animal hosts for Giardia spp. in California's Sierra Nevada mountains. Davis, CA: Cooperative National Park Resources Studies Unit; 1983; Technical Report No. 11. 21 p.

Suk, T.J., and J.L. Riggs. Occurrence of Giardia in cattle. Sacramento, CA: U.S.D.I. Geological Survey, Water Res. Div.; (in preparation).

Suk, T.J., S.K. Sorenson, and P.D. Dileanis. A survey of back-country streams for cysts of Giardia. Sacramento, CA: U.S.D.I. Geological Survey, Water Resources Division; (in preparation).

Temple, K.L., A.K. Camper, and R.C. Lucas. Potential health hazard from human wastes in wilderness. J. Soil and Water Cons. 37(6):357-359; 1982.

Wallis, P.M., J.M. Buchanan-Mappin, G.M. Faubert, and M. Belosevic. Reservoirs of Giardia spp. in Southwestern Alberta. J. Wildlife Dis. 20(4):279-283; 1984.

Wolfe, M.S. Symptomatology, diagnosis, and treatment. In: Erlandsen, S.L., and E.A. Meyer, eds. Giardia and Giardiasis. New York, NY: Plenum Press; 1984: 147-161.

CONCEPTIONS AND BEHAVIORS OF RECREATIONISTS REGARDING WATER QUALITY IN ROCKY MOUNTAIN NATIONAL PARK

Nancy P. Cowdin

ABSTRACT: Recreationists returning from two high-elevation contiguous basins in Rocky Mountain National Park were surveyed 1) to examine conceptions and behaviors of recreationists regarding water quality 2) to identify water consumers 3) to determine possible correlation between water consumption and incidence of giardiasis and 4) to quantify the amount of potential watershed contamination by human fecal material. Of the 556 recreationists surveyed, 445 (80 percent) did not drink water from a natural source. Of this group, 376 (84 percent) gave fear of illness as a rationale while 94 persons (25 percent) mentioned Giardia specifically. Of those persons interviewed who drank stream or lake water (111 or 20 percent), 35 (32 percent) used some method of purification, 76 (68 percent) drank untreated (raw) water. Of water consumers participating in a telephone follow-up interview (86 percent), 3 (3 percent) experienced some symptoms of giardiasis. There were, however, no medical confirmations of infection. Of the total group surveyed, 17 (3 percent) left fecal waste in the study area, presenting potential for watershed contamination by human sources.

INTRODUCTION

An ever-growing concern exists regarding the advisability of water consumption by recreationists in wildland areas. Articles addressing this question have been springing up with greater frequency in response to fear by backcountry users of water-related illnesses, in particular, giardiasis (Knotts 1983; Manley 1983; Wilson 1984; among others). Information on Giardia lamblia, the parasite causing giardiasis, as well as other water-borne pathogens is available to the public at large through agencies such as the National Park Service and Forest Service (USDA Publications 1980, 1981). The extent to which this information is used by the public is not known.

Studies have shown that public perception of water quality is largely based upon visual attributes (Aukerman 1971; Walsh and others 1978). At the same time, the water found in most mountain areas is astonishingly clear. It is important to backcountry managers and others concerned with public health to know what information is getting out into the public, how it is being received and what water-use practices are resulting.

This study was done concurrently with an investigation of fecal coliform bacteria and Giardia lamblia in the watersheds of the aforementioned basins. Results established that Giardia was present at the time of sampling at certain sites along the watershed in low concentrations (see Kunkle and others, 1985). As Giardia is both endemic and epidemic in Colorado (Wright and others 1977) and is both carried and transmitted by humans, knowledge of public behavior provides information relating to public health and to parasite transmission.

BACKGROUND-GIARDIA

Although the organism Giardia lamblia was identified as early as 1691 by Anton van Leeuwenhoek and formally described by Lambl in 1859, its study as a pathogenic parasite of health concern to humans has been fairly recent (Bemrick 1984).

Giardia spp. is a flagellated protozoan which when ingested by a suitable host is capable of replicating at a high rate. The result is the production of millions of organisms which line the intestinal walls causing symptoms of gastric distress including diarrhea, abdominal distention, flatulence and malabsorption. Studies have shown that the Giardia cyst, the form in which it is found outside of a host, remains viable in cold water (characteristic of mountain streams) for up to two months. Giardia from certain animal species, as well as that from humans, may cause an infection to humans (Meyer and Jarroll 1980). Expression of symptoms varies among individuals ranging from a generally brief, acute stage followed by a subacute and chronic stage of mild to moderate symptoms, which can be persistent or recurrent. An asymptomatic cyst-passing stage of undetermined duration can also occur (Wolfe 1948). Asymptomatic individuals can inadvertently carry and transmit Giardia cysts.

OBJECTIVES

Reported here is a portion of the preliminary findings of this investigation. A complete analysis and interpretation of data will be available at a later date. The objectives to be covered here are as follows:

* To establish a water consumer/nonconsumer profile of recreationists using the basins.

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* To find if those drinking stream or lake water
  a) practice water purification and, if so, what method(s) is used
  b) experience illness as a result of drinking study-area water.
* To examine user conceptions as a result of water quality, knowledge of Giardia and how this relates to user behavior.
* To determine the extent of human fecal pollution occurring in the area.

THE STUDY AREA

Two contiguous high-elevation basins, Loch Vale and Glacier Gorge, lie in the southcentral portion of Rocky Mountain National Park (fig. 1). These areas are heavily used by backcountry recreationists for camping, hiking, fishing and rock climbing. The junction of the trails leading into these basins is found approximately two miles (3.2 km) from Glacier Gorge trailhead. Both trails follow streams, adjoining or crossing them along the way, providing ample water access to hikers. Each trail leads to a series of popular lakes. A designated campground is included in each basin. At the upper reaches of each basin are bivouac areas used by rock climbers for overnight stays. The Loch Vale trail leads to Sky Pond, an alpine area 10,920 feet (3.326 m) in elevation. The Glacier Gorge trail ends at Black Lake, near timberline at 10,600 feet (3,228 m) in elevation. Hikers may continue beyond Black Lake to a shelf above (11,560 feet or 3,521 m) on which is found several lakes as well as access to several climbing areas, including Longs Peak (14,211 feet or 4,332 m).

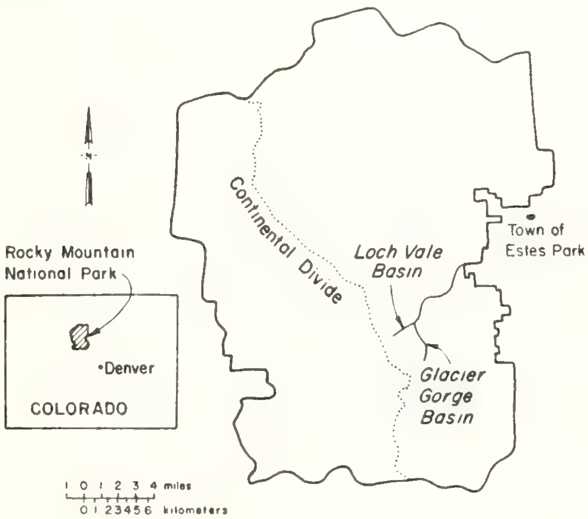

Figure 1.--Rocky Mountain National Park, showing relative location of the study area and the Park's location in Colorado (inset).

METHODOLOGY

A questionnaire interview was administered at the junction of trails returning from the two basins beginning in late July and continuing through mid-September during the summer of 1984. Five hundred fifty six (556) individuals were surveyed during the summer this time. Questions asked were open-ended in form to minimize bias of the respondent.

The interview established a profile both of water consumer and non-consumer using these basins. Non-consumers were asked to give a rationale for their choice not to drink water from area lakes or streams. Special note was taken of those citing knowledge or experience with water-borne illness, giardiasis in particular. Water consumers were asked to identify sites where water was taken, whether or not wildlife was seen in the area, if water purification was practiced and, if so, what method was used.

All individuals interviewed were asked the location and manner of disposal of fecal material in the study area, if applicable.

In addition, individuals using study area water were asked to participate in a follow-up telephone interview conducted several weeks later. The telephone interview asked for identification of symptoms which would indicate possible water-related illness, conceptions of water purity and water purification practices and specific knowledge of and/or exposure to Giardia lamblia.

RESULTS

The majority of persons interviewed were day hikers (94 percent), approximately 80 percent of whom carried their own potable water supply with them into the backcountry. It should be noted that the area is largely one of day-use although camping and bivouac use does occur. Approximately 1.3 percent of those surveyed used bivouac sites while 4.5 percent were campers.

Of the recreationists interviewed, 80 percent (445) did not drink water from the study area leaving 20 percent (111) who drank from area streams or lakes. Of those who drank, 66 percent drank raw water. This represents 14 percent of the total number surveyed. The remaining 33 percent (7 percent of total) treated their water, boiling being the preferred method (see table 1).

Of the water consumers participating in the follow-up interview, four persons indicated having experienced some illness following their return from the area. An incubation period needed for the expression of symptoms of giardiasis was taken into account. Three persons reported diarrhea, although one of these drank additional water from outside the study area. One person reported an episode of vomiting.

It has been suggested that episodes of diarrhea under times of stress could be an indicator of exposure to Giardia. The follow-up interview showed that 26 percent of the respondents reported the occurence of diarrhea during stressful times.

When non-drinkers were asked to give a rational for their decision not to drink, 63 percent gave

fear of illness as a reason and 21 percent mentioned Giardia specifically. Three percent (3 percent) reported having had giardiasis at some time in their past and 6.2 percent knew someone with giardiasis.

Twenty percent (20 percent) gave the National Park as a source of information for their decision not to drink water in the area, 4.2 percent cited outside literature (magazines, newspaper articles, etc.) as an information source and 3.8 percent gave credit to an organization or club (Colorado Mountain Club, Y.M.C.A. and others).

Of those persons choosing to drink the water, 56 percent had heard of Giardia. To this regard, questions were asked to determine the extent and accuracy of those stating knowledge of Giardia. This as well as other educationally related information is currently under analysis.

Three (3 percent) of the total number interviewed left fecal waste in the study area. The majority of these individuals (61 percent) buried the waste in soil while 23 percent left waste exposed, 8 percent buried waste under rocks and the remainder were not indicated.

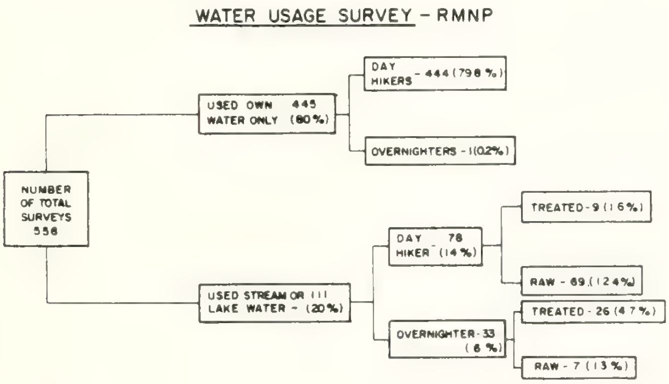

Figure 2.--Water use by day hikers and overnight hikers in the study area.

DISCUSSION

It is apparent that a large proportion of the public is aware that risks are involved in drinking raw water in the backcountry. Many of those who drank water in the study area knew of the possibility of contracting an illness such as giardiasis from water consumption but indicated that either it was worth the risk or stated that they had been drinking water in the backcountry for years with no adverse effects.

Research has shown a strong possiblity of the existence of acquired immunity in persons who inhabit or are frequent visitors to backcountry areas (or areas where minimal water treatment occurs) (Barbour and others 1976; Moore and others 1969). Rendtorff (1975) states that 85 percent of infections may spontaneously cure whereby said individuals would be unaware of a temporary infection.

With wilderness use on the rise, probabilities of diminishing water quality also rise. Continued and perhaps increased efforts should be made to educate the public regarding the risks of drinking water in the backcountry. The fact that drinking untreated stream water poses some health risk to the recreationist merits this attention.

However, it is important to consider impacts upon the quality of wilderness experience afforded the recreationist. Water quality in many backcountry areas remains pristine. Moreover, water purification reduces the likelihood of contracting a water-related illness. This is a viable and preferred option for many. As day-use is the most common in these areas, and as 91 percent of the raw water drinkers were day hikers, it is this group who must be targeted for education purposes.

Table 1.--Summary of water purification methods used by hikers

Treatment Method			Number of Users	Percent of Total Number Treating Water (N = 35)
Iodine:	Potable Aqua[1]		5	14%
	Coghlan's[1]		2	5%
		Total	7	20%
Filtration:	Aquatech[1]		4	11%
	First-Need[1]		5	14%
		Total	9	26%
Boiling:	10 minutes		2	5%
	5 minutes		5	14%
	2 minutes		2	5%
	1 minute		8	23%
	Unspecified		2	5%
		Total	19	54%

[1]Product trade names.

Of equal importance is the potential for increased watershed contamination by human fecal pollution. While only 3 percent of the total surveyed left fecal material in one of the basins, this is significant when considering the many thousands of visitors to these areas. Public education must include promoting good backcountry sanitation practices in addition to alerting the public as to the potential impacts on water quality created by improper waste disposal.

REFERENCES

Aukerman, R.; Bishop, D. W. Water quality criteria for recreation users--user preceptions. Water Resources Center, University of Illinois, Office of Water Resources Research, Department of the Interior; 1971. 134 p.

Aukerman, R. User preception--water quality criteria for recreation site comparisons. Office of Water Resources Center, University of Illinois, Office of Water Resources Research, Department of the Interior, Ph.D. dissertation and microfiche at University of Oregon; 1973. 326 p.

Barbour, A. G.; Nichols, C. R.; Fukushima, T. An outbreak of giardiasis in a group of campers. The American Journal of Tropical Medicine and Hygiene. 25: 384-389; 1976.

Bemrick, W. J. Some perspectives on the transmission of Giardiasis. In: S. L. Erlandsen and E. A. Meyer, eds. Giardia and giardiasis: Biology, pathogenesis and epidemiology. New York: Plenum Press; 1984.

Knotts, D. M. Purifying water in the wild. Sierra. 68(4): 57-59; 1983.

Kunkle, S.; Cowdin, N.; Wilson, J.; Grondin, J.; Ricketts, T.; Flora, M. Giardia in streams and wildlife of two backcountry watersheds in Rocky Mountain National Park, Colorado. National Park Service Water Resources Division, Fort Collins, Colorado. (In preparation)

Manley, H. An easy preventative for "backpacker's disease." Backpacker. 11(2): 95; 1983.

Meyer, E. A.; Jarroll, E. L. Giardiasis. American Journal of Epidemiology. 111(1): 1-12; 1980.

Moore, G. T.; Cross, M.; McGuire, D.; Mollohan, C. S.; Gleason, N. N.; Healy, G.; Newton, L. H. Epidemic giardiasis at a ski resort. New England Journal of Medicine. 281(8): 402-407; 1969.

Rendtorff, R. C. Giardia in water. Letter to the editor. Annals of Internal Medicine. 82(2): 280: 1975.

U.S. Department of Agriculture, Forest Service. What bugs you? U.S. Government Printing Office, Washington, DC; 1980. 1980-680-250.

U.S. Department of Agriculture, Forest Service. Backcountry safety tips: Pacific Southwest Region. Brochure.

Walsh, R.; Erickson, R.; McKean, J.; Young, R. Recreation benefits of water quality: Rocky Mountain National Park, South Platte River Basin, Colorado. Colorado State University Experiment Station Projects; 1978. 264, WR-118 and 1769.

Wilson, A. Mysterious Giardia. World Health. 1984 March: 22-24.

Wolfe, M. S. Giardiasis: Symptomatology, diagnosis, and treatment. In: S. L. Erlandsen and E. A. Meyer, eds. Giardia and giardiasis: Biology, pathogenesis, and epidemiology. New York: Plenum Press; 1984: 147-159.

Wright, R. A.; Spencer, H. C.; Brodsky, R. E.; Vernon, T. M. Giardiasis in Colorado: An epidemiologic study. American Journal of Epidemiology. 105(4): 330-336; 1977.

ANGLERS' PERCEPTIONS OF TOXIC CHEMICALS IN RIVERS AND SPORT FISH

Edward Udd and Joseph D. Fridgen

ABSTRACT: Anglers' responses to toxic chemical contamination of rivers and sports fish were tested on three rivers in Michigan. Across three levels of contamination, there was no difference among anglers in terms of their awareness of, responses to or avoidance of contaminants, even on the river with high levels of toxic chemical contamination. Management, health and recreation experience implications are discussed.

INTRODUCTION

A range of factors influence outdoor recreation experiences. Most often such factors are benign. Unfortunately, new ominous threats are beginning to influence outdoor recreation experiences; these modern day threats include air pollution, acid rain and toxic chemicals. A unique and troublesome characteristic of these threats is the fact that they are often not detectable to the human senses (for example, sight, smell, taste).

Toxic chemicals are the focus of this study. Toxic chemicals pose a unique threat in that they are a direct danger to human health as well as to the natural environment. Toxic chemicals are known to be a cause of cancer and of birth defects, as well as a cause of other problems such as nausea and severe headaches if consumed in sufficient quantities (MDNR 1984b; Collins 1978; Schweitzer 1983; Holdgate and others 1982; Eckholm 1982; Logue and others 1981). Toxic chemicals are being found in many types of environments and, unfortunately, are not excluded from recreation environments. In this study we are particularly concerned with the presence of toxic chemicals in environments used by sport anglers.

Anglers are at risk when they consume their catch containing hazardous levels of toxic chemicals. The reason that fish may contain hazardous levels of toxic chemicals, even in otherwise clean water, is that toxic chemicals "bioaccumulate" in the fatty tissue of the fish (Train 1976). Bioaccumulation simply means that as water is passed through the body of a fish the toxic chemicals are removed and stored in the fatty tissue. This process, over time, may result in levels of toxic chemicals in the fish many times higher than the contamination levels in the surrounding water (Train 1976).

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In Michigan, the Department of Natural Resources and the Public Health Department have published warnings regarding the consumption of contaminated fish. Each year, the warnings are printed in the Fishing Guide which is passed out to those who purchase fishing licenses (MDNR 1984a). Depending upon the particular location, three levels of warning are published:

1) All species of fish are considered unsafe to eat in any amounts.
2) Certain species of fish should not be consumed in large amounts (greater than 26 pounds annually) or not at all by high risk groups such as pregnant women or children.
3) No warning about toxic chemicals. (MDNR 1984a)

The warnings are published to protect the health of anglers by informing them of a potential threat to their health if consumption occurs.

Anglers' Responses to Toxic Chemicals

Limited research exists on the relationship between toxic chemicals and angler behavior. To provide guidance in approaching this problem this study draws upon natural hazards research on air pollution, water pollution (debris, foul smell), floods, earthquakes and tornados. While these studies provided a reasonable approximation to the study problem there are three significant differences.

1) Most natural hazards have an identifiable low point after which it can be observed that the situation is improving. With toxic chemical contamination such a low point is lacking. The worst may have already passed or it may lie years, even decades, down the road (Baum and others 1983).

2) A few representative samples of natural hazards literature (Jackson 1981; Hanson and others 1979; Preston and others 1983; Hansson and others 1982; Evans and Jacobs 1981), reveal that most respondents either live in the path of the potential hazard or the threat is a part of their everyday living environment (for example, air pollution). With anglers, toxic chemicals in fish only become a threat when people enter a specific environment (where hazardous levels of toxic chemicals exist), participate in a specific recreation activity (fishing), and consume the fish they catch (and sometimes only when consumed in large quantities).

3) Lastly, toxic chemicals are not detectable by the human senses. Unlike floods, earthquakes, fires or tornados there are no physical signs or damage to aid in the identification of the hazard itself (Baum and others 1979). People must rely

on specialized measuring instruments or expert help to determine if toxic chemicals are present in particular environments.

Response to Natural Hazards

This study examines the response of anglers to the presence of toxic chemicals as if anglers were being confronted by a "typical" natural hazard. In such a situation anglers need to decide how they will respond to the presence of the hazard. One theoretical framework to predict these decisions would be the maximization of the expected utility model which states "... that the wise decision maker chooses that act whose expected utility is greatest." (Slovic and others 1974, p. 188). Such decisions, by necessity, require complete information of all potential alternatives. The adoption of such a model would lead to the expectation that anglers would choose to maximize their well-being by not consuming fish contaminated by toxic chemicals.

An alternate model suggests that people make less than rational choices based on less than perfect information. This theory of bounded rationality "... asserts that the cognitive limitations of the decision maker force him to construct a simplified model of the world to deal with it." (Slovic and others 1974, p. 189). This theory suggests that anglers would often make less than optimal decisions when deciding whether or not to consume fish contaminated by toxic chemicals. Based upon research available, this latter theory appears to be the better model to describe people's decisions when confronted by a range of natural hazards (Slovic and others 1974; Burton and others 1978).

When confronted by natural hazards people generally decide to behave in one of four ways:

1) <u>Avoidance</u> of the natural hazard.
2) <u>Mechanical circumvention</u> of the hazard (for example, the use of a boat to escape from a flood).
3) Behaviors to <u>cope</u> with the natural hazard. These coping behaviors serve to reduce the risk associated with the natural hazard.
4) <u>Adaptation</u>. This behavior is simply acceptance of the natural hazard without any physical actions to minimize potential harm. (Hewitt and Burton 1971, p. 140).

Each of these potential behaviors is examined in this study with the exception of mechanical circumvention. This latter behavior is omitted because there are no known ways to mechanically circumvent the presence of toxic chemicals while fishing or during consumption of the catch.

Research Questions

To respond to a hazard, individuals need to be aware of its presence and be somewhat accurate in their estimation of its magnitude. "It seems likely that the process of choice does not begin until after a first threshold of awareness of actual or anticipated loss is reached." (Burton and others 1978). As already discussed, toxic chemicals are not directly detectable by the senses. Therefore, anglers are generally dependent upon other sources to form their "perceptions" and impressions of the levels of toxic chemicals present in the waters they are fishing. One central question of this study is whether anglers are aware of the differences between high, medium and no toxic chemical contamination in sport fishing waters?

Once the presence of toxic chemicals has been perceived, the behavioral responses to the threat are of interest. A review of the literature by Sims and Baumann (1983) suggests there is, at best, only a weak relationship between the adoption of behavioral responses and awareness of a natural hazard. The last part of this study deals with exploring what, if any, behavioral responses anglers participate in when confronted by toxic chemicals in the rivers they fish and their catch.

METHODS

Sampling

Three levels of toxic chemical contamination in selected rivers were defined by the warnings published by the Michigan Department of Natural Resources. Those waters where all fish are banned for consumption were assigned to the high contamination condition. Those waters receiving the lesser warning were placed in the medium contamination condition. And those waters for which no warnings were published were placed into the no contamination condition. The Saginaw River, the Kalamazoo River and the Grand River were chosen to represent the high, medium and no toxic chemical contamination conditions respectively.

Sample sites were chosen based on several criteria. First, sites should have no admission charge and be open to all the public. The second criterion required that each sample site be within a fifty mile radius of at least one medium size city in Michigan ($\geq$ 50,000). Third, sites were chosen within three hours driving distance of Lansing, Michigan. Lastly, two sites were chosen per condition (river) with the exception of the Kalamazoo River. Five sites were chosen on the Kalamazoo due to the more dispersed nature of anglers on that river.

From July 1st through Labor Day during the summer of 1984, 318 personal interviews were conducted with at least 100 from each of the study conditions. Each condition was randomly assigned to predetermined sampling days during that time frame. The sampling scheme was stratified to insure an equal number of sampling days across the conditions and equal number of sampling time at each of the study sites. Individuals were chosen at random from each systematically encountered group of anglers at each site. The length of each interview averaged about fifteen minutes; the response rate was 94%.

Measuring Instrument

To measure perceptions of toxic chemicals a thirteen item, six point scale was constructed. This scale was composed of three subscales which measured perceptions of toxic chemicals in the water (5 items), perceptions of toxic chemicals in the fish (4 items) and perceptions of health threats from consuming toxic chemicals (4 items). Due to the low reliability of the health threat subscale (Cronbach's alpha = .50) those items were excluded from this analysis. Cronbach's alpha for the other two subscales was .80 for the perception of toxic chemicals in the fish and .83 for the perception of toxic chemicals in the water. These two scales were subsequently merged to provide a single indicator for purposes of this paper. Those cases which contained missing values for the scale items were not included in the analysis. The reliability coefficient for the merged scale was .91 with inter-item correlations ranging from .35 to .76.

In addition, anglers were asked to rate the level of toxic chemicals they felt was present in the water on a single ten point index toward the end of the interview. The question read: "With one being no toxic chemicals are present in this water and ten being high levels of toxic chemicals are present, how would you rate the level of toxic chemicals in this water"? Other variables in this study included: planned consumption of the catch; avoidance of waters contaminated by toxic chemicals; fish cleaning and preparation techniques; cooking methods; response to the MDNR warning; and selected demographics.

RESULTS

Perception of Toxic Chemicals

Respondents' average scores on the nine item toxic chemical perception scale across the three rivers can be seen in table 1. The higher the score, the more respondents agreed on the average that toxic chemicals were present in the fish and water they were fishing. The scale scores could range from 1 - 6. There were no significant differences between the responses of the three groups.

Table 1.--Mean perception scale scores across contamination levels

	Rivers/Contamination Levels		
	Grand (None)	Kalamazoo (Med.)	Saginaw (High)
X	3.8	4.2	4.1
SD	1.2	1.2	1.4
N	100	95	93

Note: ANOVA--df = 2, 285; F = 1.85; P<.25.

Complementing these results, an analysis of variance of the 10 point rating scale, where respondents were asked to rate the levels of contamination of the river they were fishing at the time of the interview, resulted in similar findings. Across the three conditions, the means were 4.1 for the Grand, 4.7 for the Kalamazoo, and 4.6 for the Saginaw; the SD and N ranged from 1.9-2.2 and 97-109, respectively. There was no difference in anglers' assessment of the level of contamination for the respective rivers on the single item index (F = 2.24; df = 2, 305; P<.25).

Behavioral Responses

Two items were used as indicators of avoidance behavior. The first asked anglers if they had ever avoided fishing in waters in Michigan because they believed those waters were contaminated by toxic chemicals. Approximately twenty percent of the anglers questioned said they had avoided such places in the past (table 2). The second asked anglers if they would avoid the site they were fishing at the time of the interview, if they knew toxic chemicals were present in the waters. The number of anglers who said they would avoid the site rose to almost fifty percent across the rivers (table 2).

Perhaps the most straightforward form of coping with toxic chemicals in fish is simply not to eat the fish. However, over fifty percent of the anglers questioned said they planned on consuming the fish they caught the day of the survey (table 3) When asked later in the interview if they would consume those fish if they knew toxic chemicals were present, the planned consumption dropped dramatically (table 3). The largest drop in planned consumption occurred among anglers on the Saginaw River (from 57% to 7%) where all fish were considered unsafe to eat due to high levels of toxic chemicals already present.

By carefully preparing the fish they catch, such as filleting, skinning or removing fatty belly flap, anglers can reduce their health risks when

Table 2.--Anglers reporting avoidance of contaminated waters

	Rivers/Contaminated Levels			
	Grand (None)	Kalamazoo (Med.)	Saginaw (High)	Totals
During past year				
Yes	14%	20%	26%	20%
N	108	105	98	311
If knew present water was contaminated				
Yes	53%	44%	48%	48%
N	97	105	109	311

Table 3.--Planned consumption of fish

	Rivers/Contamination Levels			
	Grand (None)	Kalamazoo (Med.)	Saginaw (High)	Totals
Plan to consume catch				
Yes	49%	60%	57%	55%
N	112	106	100	318
Consume if knew fish were contaminated				
Yes	9%	25%	7%	14%
N	108	105	98	311

consuming contaminated fish. Respondents were asked about preferred cleaning and preparation procedures. Scaling and filleting are the most common techniques used by anglers (38% and 47%, respectively). Two other important techniques, skinning (30%) and removing the fatty belly flap (17%) are less common, although appropriate and important coping responses to the presence of toxic chemicals in the fish. For those anglers who said they would eat fish containing toxic chemicals (N=54), filleting becomes even more popular (62%) as does removing the belly flap (33%) with skinning staying the same (29%). This trend suggests a degree of coping with appropriate behavioral responses in the preparation process.

In addition, anglers can reduce their health risk from toxic chemicals through various cooking methods such as broiling, barbecuing or baking their catch. Frying is not the recommended method for cooking fish containing toxic chemicals. The results indicate that frying is the most popular cooking method, even among those anglers aware that their catch may contain toxic chemicals (76% and 83%, respectively). The benefits and preference for frying fish seem to outweigh the costs of changing cooking procedures to minimize toxic chemical consumption and exposure.

The Michigan Department of Natural Resources issues a warning about toxic chemicals in Michigan waters and fish. This warning is issued to each purchaser of a fishing license. It is possible that some respondents had not read the MDNR warning. To investigate this question, the consumption behavior of anglers who said they had read the MDNR warning was compared to those who said they had not read the MDNR warning. No significant differences were found between the two groups (x^2=1.08; df=2; N=300). Over fifty percent of the respondents indicated they were going to consume the fish irrespective of the warning.

Table 4 presents the income, age and education of the anglers interviewed across all three conditions. Anglers on the Saginaw appear to have lower incomes and less education than anglers on the Kalamazoo or the Grand. Anglers on the Saginaw are also slightly older than anglers using the other two rivers.

Table 4.--Demographic profile of anglers

	Rivers/Contamination Levels			
	Grand (None)	Kalamazoo (Med.)	Saginaw (High)	Totals
Income				
Mean	$23,750	$32,027	$22,082	$26,182
Median	21,966	20,002	15,933	19,012
SD	15,115	71,733	28,667	46,356
N	101	101	83	285
Age				
Mean	37.8	39.8	41.1	39.5
SD	13.3	14.2	16.1	14.5
N	110	106	99	315
Education				
Mean	12.4	11.6	10.9	11.7
SD	2.7	2.8	3.4	3.0
N	110	105	99	314

DISCUSSION AND CONCLUSIONS

Awareness and Perception

The maximization of expected utility model suggests that people will respond to their environment in a rational manner. Presumably this includes the preservation of good health. However, the results of this study suggest that something else quite different is occurring with anglers when they are confronted with toxic chemicals.

Anglers lack awareness of the presence of toxic chemicals, consume contaminated fish and do not show unanimity in their responses to the hypothetical presence of toxic chemicals. Such behavior suggests that the maximization of expected utility model is not appropriate for explaining the decisions that anglers make when confronted with toxic chemicals. The alternate proposed model of bounded rationality described in more detail by Slovic and others (1974) appears to better describe this relationship. Anglers make less than rational decisions based on less than perfect knowledge about toxic chemicals.

Incomplete knowledge leads to misperceptions by anglers. In this study, the fishing sites and the sport fish were contaminated by different levels of toxic chemicals. However, anglers did not "perceive" these differences. Their perceptions, as indicated by the perception scale, were the same whether they were fishing on a river where all fish were considered unsafe to eat or a river where no hazardous levels of toxic chemicals existed. Such misperceptions hinder anglers' attempts to protect themselves from the potential hazards of toxic chemicals. If a hazard is not perceived, then in effect, a hazard does not exist in the mind of the angler regardless of the reality.

Health Threat Implications

The results of this study suggest that toxic chemicals constitute a threat to anglers on selected rivers in Michigan. Anglers are consuming fish known to contain hazardous levels of toxic chemicals. In addition to consuming contaminated fish, anglers also appear to be unaware of the presence of toxic chemicals. While most anglers reported that they would stop fishing in waters that contained toxic chemicals, two thirds of the respondents were fishing on waters that contained toxic chemicals. Anglers who are unaware of the presence of toxic chemicals cannot take any action to avoid them. Consequently, their health is unknowingly being threatened.

Management Implications

The presence of toxic chemicals appears powerful enough to modify the behavior of anglers if it is perceived correctly. While confused about where toxic chemicals existed, anglers reported that they would take strong actions if they had accurate knowledge about toxic chemicals. Planned avoidance behavior rose dramatically and planned consumption dropped dramatically as well when anglers were hypothetically faced with toxic chemicals at their fishing site and in their catch. These behaviors, by necessity, change the nature of the fishing experience for these anglers.

Regulations, however, can modify the recreation experiences as well. Too many regulations may lead to antagonism between recreationists and land managers (Lucas 1982). The "soft" approach taken by the Michigan Department of Natural Resources seems to have minimized this antagonism, but sizeable groups of anglers are still not aware of the ban placed on selected river sites. In the case of toxic chemicals, more forceful, direct regulations may be necessary to protect the health of anglers.

From the results of this study it appears that the behavior of anglers will be modified as they become aware of the degree and location of toxic chemicals. Avoiding favorite fishing spots or fishing only for "fun" may lead to a certain degree of loss from the fishing experience. However, we do know that anglers fish for many reasons other than just catching fish (Hendee and others 1977; Driver and Knopf 1976; Moeller and Engelken 1972). Still the extent to which not being able to consume the fish influences the overall satisfaction with the fishing experience remains unknown.

Toxic Chemicals and Recreation

Toxic chemicals are not restricted to appearing in any specific type of environment. Toxic chemicals can occur in hazardous levels almost anywhere. There are hundreds of sites throughout the U.S. that have been identified as being dangerous due to the presence of toxic chemicals. How these sites will affect recreation behavior is unknown. However, this study has demonstrated that toxic chemicals pose a three-fold problem for recreationists. First, toxic chemicals are difficult to detect. Second, they have the potential to alter the recreation experience. Third, they pose legitimate health threats in certain circumstances. The manager is left with the problem of protecting the health of the recreationists, while trying to maintain the high quality of the recreation experience.

At the wilderness end of the spectrum there is also a threat. Unseen hazards such as air pollution and human sewage are already a problem. Acid rain is altering the chemistry of formerly pristine lakes and streams and other toxic chemicals have certainly reached these environments as well. The question remains: how do these unseen hazards influence and interact with recreation experiences of wilderness users? Are wilderness users more "sensitive" to contamination of the environment?

Future Research

Answering these questions leads to the first possibility for future research. Not only do these questions need to be addressed for toxic chemicals, but also for such other unseen hazards as air and water pollution, acid rain and bacterial contamination. Anglers have a high potential for being affected by toxic chemicals because of their consumption behavior. Are other types of recreation also affected in a similar fashion? Does the type of recreation environment play a role in users' sensitivity to unseen hazards? For example, it would be expected that wilderness users would be more sensitive to disruptions of their environments than someone who lives in an area where toxic chemicals are commonly found.

This study utilized natural hazards literature as a theoretical base. Other theoretical approaches could prove useful and these include: communication theory, environmental stress research, risk taking and assessment theory and cognitive dissonance theory.

It is a symptom of our modern society that as we advance technologically we also see an increase in associated problems. Our former havens from urbanization are turning out to be no less vulnerable to technology than our homes or work places. While we cannot easily or quickly solve these problems of technology, we must begin the process of understanding their resultant impacts on the recreating public through further research.

REFERENCES

Baker, E. J.; West, S. G.; Moss, D. J.; Weyant, J. M. Impact of offshore nuclear power plants: forecasting visits to nearby beaches. Environment and Behavior. 12(3): 367-407; 1980.

Baum, A.; Fleming, R.; Davidson, L. M. Natural disaster and technological catastrophe. Environment and Behavior. 15(3); 333-354; 1983.

Burton, I.; Kates, R. W.; White, G. F. The environment as hazard. New York: Oxford; 1978.

Collins, R. L. The strategy for cleaning up our waters. In: Toribara, T. Y. and others, eds. Environmental pollutants. New York: Plenum Press; 1978: 19-35.

Driver, B. L.; Knopf, R. C. Temporary escape: one product of sport fisheries management. Fisheries. 1(2): 21-19; 1976.

Eckholm, E. P. Down to Earth. New York: W. W. Norton & Co.; 1982: 98-109.

Evans, G. W.; Jacobs, S. V. Air pollution and human behavior. Journal of Social Issues. 37(1); 95-125; 1981.

Hanson, S.; Vitek, J. P.; Hanson, P. O. Natural disaster: long-range impact of human response to future disaster threats. Environment and Behavior. 11(2); 268-284; 1979.

Hansson, R. O.; Noulles, D.; Bellovich, S. J. Knowledge, warning and stress: a study of comparative roles in an urban floodplain. Environment and Behavior. 14(2); 171-185; 1982.

Hendee, J. C.; Clark, R. N.; Dailey, T. E. Fishing and other recreation behavior at high-mountain lakes in Washington state. Research Paper PNW-304. Portland, OR.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment; 1977. 27 p.

Hewitt, K.; Burton, I. The hazardousness of a place: a regional ecology of damaging events. Toronto: University of Toronto Press; 1971.

Holdgate, M. W.; Kassas, M.; White, G. G., eds. The world environment 1972-1982: a report by the United Nations Environment Programme. Dublin: Tycooly International Publishing Limited; 1982.

Jackson, E. L. Response to earthquake hazard: the west coast of North America. Environment and Behavior. 13(4), 387-416; 1981.

Logue, J. N.; Melick, M. E.; Hansen, H. Research issues and directions in the epidemiology of health effects of disasters. Epidemiologic Reviews. 3:140-162; 1981.

Lucas, R. Recreation regulations - when are they needed? Journal of Forestry. 80(3): 148-151; 1982.

Michigan Department of Natural Resources. Michigan fishing guide: 1984. Lansing: State of Michigan; 1984a.

Michigan Department of Natural Resources Hazardous waste management in Michigan. Lansing: State of Michigan; 1984b.

Moeller, G. H.; Engelken, J. H. What fishermen look for in a fishing experience. The Journal of Wildlife Management. 38(4): 1253-1257; 1972.

Preston, V.; Taylor, S. M.; Hodge, D. C. Adjustment to natural and technological hazards: a study of an urban residential community. Environment and Behavior. 15(2): 143-164; 1983.

Schweitzer, G. E. Toxic chemicals: steps toward their evaluation and control. In: Kay, D. A.; Jacobson, H. K., eds. Environmental protection: the international dimension. Totowa: Allanheld, Osmun & Co., Publishers, Inc.; 1983: 22-24.

Sims, J. H.; Baumann, D. D. Educational programs and human response to natural hazards. Environment and Behavior. 15(2): 165-189; 1983.

Slovic, P., Kunreuther, H.; White, G. F. Decision processes, rationality and adjustments to natural hazards. In White, G. F., ed. Natural hazards: local, national, global. New York: Oxford Press; 1974: 187-205.

Train, R. E. Environmental protection prescription for health. In: National conference on polychlorinated biphenyls; 1976 March; Washington. Washington, D. C.: Environmental Protection Agency; 1976: 7-9.

Section 6. Wilderness Use and User Characteristics Research

USE AND USER CHARACTERISTICS: IMPROVED KNOWLEDGE IS VITAL

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Session Coordinator

In many respects, the information needs of recreation managers for an understanding of the phenomena associated with outdoor recreation are similar to those of wildlife managers; knowledge about the number and type of users, their characteristics, use patterns, and site preferences (for recreation habitat) is as fundamental to effective recreation management as is knowledge about the number and characteristics of various types of wildlife species (and what constitutes their habitat) is to effective wildlife management. Such knowledge aids in predicting the effects of alternative management and social changes on the choices users make and on the quality of their experiences.

The papers presented at this conference cut across a variety of issues important in understanding the nature of the use and users of wilderness. An historical, albeit qualitative, perspective is offered by Merriam in his paper reviewing 25 years of experience in the Bob Marshall Wilderness Complex. Lucas provides a more structured examination of trends of use in the same area and the influences of visitor experience on those trends. Although based on different methods, both of these papers report similar conclusions about how the area and its users have changed.

An international perspective is offered by Stankey who examines users in the Kosciusko National Park in New South Wales, Australia, and compares them to what we know about wilderness users in the United States. The evidence indicates some striking similarities, but the author cautions us about the influence of different cultures on the perceptions and use of wilderness in the two countries.

Warren looks at users of the Arctic National Wildlife Range, a little-visited wilderness in the north of Alaska. His study provides a baseline (generally absent in most areas) from which future managers can evaluate the effects of resource management and other social changes on use of this area.

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Hammitt and his colleagues focus their attention on seasonal variation in wilderness recreation and describe a study of winter recreationists. The authors point out that few "off-season" studies of wilderness users have been conducted and their findings support the need for further research in this direction. Although each of the papers presented in this session focuses on use and characteristics of users, each also relates such information to preferences and attitudes of the visitors studied.

A paper of a different orientation was prepared by Cockrell and others based on a poster presented during the conference. They examine the nature of the knowledge and reactions of graduates of wilderness education certification courses. Although the study indicates graduates are largely satisfied with their courses, knowledge levels were low.

The areas examined in these papers represent a wide range of geographic locations in dissimilar regions of this country and Australia. The papers also cut across time and are based on different disciplines. The data the authors report illustrate many similarities as well as differences between users of those areas. Each of the studies represents a positive contribution to the literature and provides clues to managers that might improve management of the areas studied. Yet, a basic problem exists when trying to interpret what these studies tell us. Due to the lack of information that provides a more representative look at the populations from which the users to these areas come, including users and nonusers, it is impossible to draw any definitive conclusions about either wilderness use or user characteristics from a national or even regional perspective.

Because of the lack of common methods, and the site-specific orientation of most past studies, their relevance for integrated planning and management from a comprehensive systems perspective must be questioned. Relatively few studies exist that cut across many areas. And, there are very few appropriately designed longitudinal studies that examine more than one area across time.

This is not to imply that studies such as those reported in these proceedings are without value. To the contrary, comprehensive knowledge about specific areas is valuable for managers of those areas. But, future studies must account for both the similarities and differences between areas and users, and need to include people who do not participate in wilderness-based recreation.

There is a great need for regional, national, and even international studies of wilderness (and nonwilderness) users. Site-specific studies are important for management of a particular area, but they are not a substitute for research that examines the interrelationships between users and areas. In the absence of research that provides a basis for evaluating the significance of studies of specific areas, we are unable to clearly understand the nature of wilderness users or their characteristics and, more important, how such information can be utilitized to make management of an integrated wilderness system more effective.

The lack of a holistic perspective inhibits effective management because it is difficult to determine the role(s) that certain wildernesses play vis a vis others, or the role that wilderness plays in comparison to nonwilderness. Proposals have been made in the recent past to conduct comprehensive studies of wilderness and nonwilderness use throughout the United States, but funding has not been available. Such studies are certainly costly, which is particularly constraining in a time of reduced budgets for all kinds of research. Yet, one must question the costs associated with not having the knowledge such studies would provide.

I hope that a major result of this conference will be to focus future studies of wilderness users (as well as nonusers) in directions that will satisfy some of these concerns. Only in this way can we expect to provide more complete answers to the "so what" question that managers ask so often.

NEARLY A QUARTER OF A CENTURY IN THE BOB MARSHALL WILDERNESS (1960-1984)

Lawrence C. Merriam

ABSTRACT: Studies of visitation and users in Montana's Bob Marshall Wilderness were compared over the period 1960 to 1984. Visitation has greatly increased with hiker use offsetting formerly predominant horse travel. Some uses are now in conflict in portions of the area and the wilderness experience has changed.

INTRODUCTION

Montana's Bob Marshall Wilderness, which comprises some 950,000 acres, straddles the Continental Divide in two national forests south of Glacier National Park (fig. 1). Administratively designated wilderness in 1940 by regulation of the U.S. Department of Agriculture, it was created wilderness by the Wilderness Act of 1964 and has become one of the nation's best known areas of its type. Since the early 1900s it has been popular with horsepackers, who use it primarily for hunting and fishing. Today there is also considerable backpacking use. Visitation has almost tripled since 1960, and management direction is toward maintaining naturalness and minimizing impact. It is now part of a larger complex that includes the new Scapegoat Wilderness (240,000 acres) to the south and the Great Bear Wilderness (280,000 acres), which adjoins it to the north (Lucas 1980).

In 1960, I studied the administration, use, and visitors of the Bob Marshall as a contribution to the National Outdoor Recreation Resources Review Commission (ORRRC) wilderness study (California 1962). It was also the subject of my doctoral study, an economic analysis based on the year 1960. I did another visitor study in 1964 and since that time have visited the area periodically with family and friends and have stayed in touch with Forest Service personnel.

Use of the Bob Marshall has increased substantially since 1960. Although horse use has declined as a percentage of total use, hiking use has increased and seasonal use has shifted from fall to summer (table 1). Floating the South Fork of the Flathead River has become an important use. With the passage of the Wilderness Act in 1964, area use restrictions and management planning increased, turning toward restoring naturalness and ensuring solitude. The addition of the Scapegoat Wilderness (1972) and the Great Bear Wilderness (1978), plus the passage of Wild and Scenic River legislation (1968), have had their effects. Also, roads to the boundaries of the Bob Marshall have been extended during the last 24 years, improving access for visitors.

Table 1.--Use, facility, and outfitted party rule changes in the Bob Marshall Wilderness, Montana, 1960-1983[1]

	1960 Pre-Wilderness Act (1964)	1983 Wilderness
Use Type		
Total visits (estimated)	5,350	13,800
Horse use (%)	94	approx. 50
Hiker use (%)	6	approx. 50
Summer season use (%)	40	80
Fall season use (%)	60	20
Facilities Present		
Ranger stations	1	0
Work centers	1	2
Active Forest Service cabins	14	13[2]
Active Forest Service lookouts	6	1
Forest Service administrative airfields	8	2[3]
Outfitted Party Controls		
Length of stay (days)	Generally not limited	14
Head of stock/party	2 head/person rule of thumb	35
Party size limit	Generally not limited	15

[1] The Bob Marshall Wilderness is part of a three-area Bob Marshall Wilderness Complex (including Bob Marshall, Great Bear, and Scapegoat Wilderness).

[2] Some cabins are being reviewed for possible removal.

[3] Emergency use only.

Once deeply versed in the management and lore of the area, I have tried to observe objectively changes in its use over time. Here I present impressions of what these changes may mean for the future management of and use research in the Bob Marshall.

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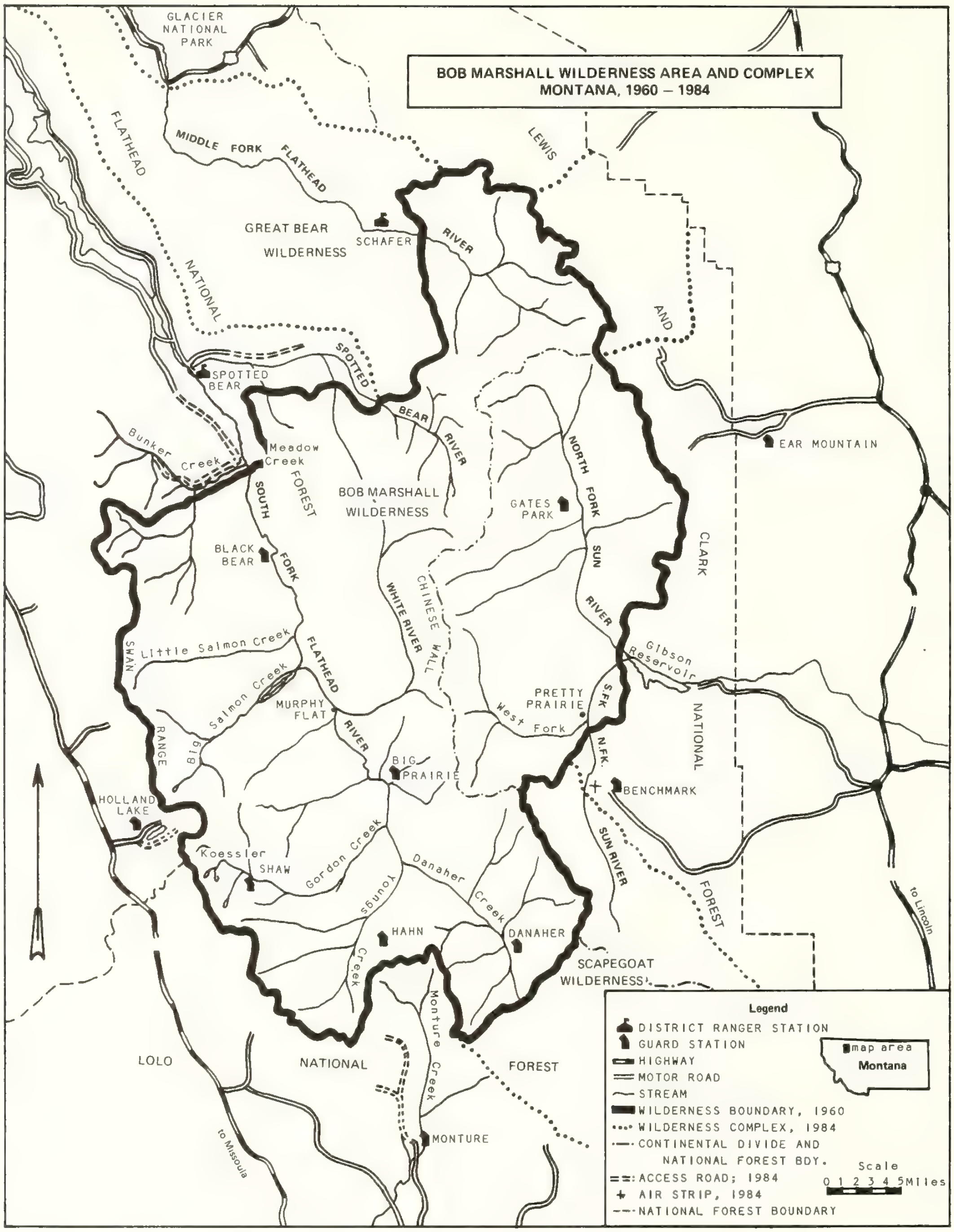

Figure 1.--Bob Marshall Wilderness and Complex--boundary and road changes 1960 to 1984.

HISTORY

In many ways the area known as the Bob Marshall Wilderness became a preserve by accident. There was no grand plan for the area and Bob Marshall's influence on it was limited, although he did perform hiking feats there -- feats that I later tried unsuccessfully to duplicate. Physiographically, the area is a maze of cutup drainages, steep narrow canyons, and a few lakes. It was opened to entry under the Forest Homestead Act of 1906, but few settlers came (Lewis 1915) and all but a few tracts had been abandoned by 1930. Access and distance to market were factors that limited occupancy. From the early 1900s, commercial outfitters successfully guided big game hunting parties in the area (Merriam 1963). The area's timber resource was considered of little value in the 1930s, much of the area having been burned heavily by repeated fires.

Forest officers in Region 1, guided primarily by regional forester E. W. Kelly and his assistant, Meyer Wolff, obtained the L-20 Primitive Area classification for three separate areas: the South Fork of the Flathead River unit, the Sun River unit, and the Pentagon unit on the Middle Fork of the Flathead and Spotted Bear rivers.

In the 1930s there was local interest in establishing an area; supporters included Olas Murie, a founder of the Wilderness Society, and Bob Cooney, later of the Montana Fish and Game Department.

Unlike many other wilderness areas (for example, the Selway-Bitterroot Area in Idaho and Montana), the Bob Marshall became a wilderness without fanfare. In 1940, following Bob Marshall's death (1939), the three units were combined adminstratively without advertisement under the Department of Agriculture U-1 Wilderness Regulation as the Bob Marshall Wilderness. At that time the area was said to be one of the first in which Bob Marshall made his hikes and explorations in Montana (USDA Forest Service 1940). Then, in 1964, under the Wilderness Act, it automatically was classified as wilderness without major controversy and under passive recreation management that emphasized protection as a horse use area, particularly for fall hunting.

Although the Bob Marshall was managed under relatively strict wilderness guidelines in the period before passage of the Wilderness Act, the overall policy was inconsistent with today's wilderness policy. When the primitive areas were designated between 1931 and 1934, policy was directed toward primitive uses of the area, not complete preservation. Under such a policy, constructing administrative buildings, work centers, lookout towers, horse trails, fences, and other facilities was logical, as was allowing outfitters and guides special use permit camps (some of which became little resort enclaves). It also made sense to develop administrative airfields for fire protection and emergency uses. At the time of classification, commercial timber was considered to be inaccessible for 30 to 50 years (1970-1990) (USDA Forest Service 1940).

Starting in the 1950s, oil companies began pressuring the Forest Service for permission to explore for gas and oil on the Sun River. Their efforts were unsuccessful (Merriam 1963).

1960 SETTING

In 1960, Forest Service management was pragmatic and oriented toward maintaining accepted practices while protecting the wilderness resource. For example, airfields at Big Prairie Ranger Station, Black Bear, and Gates Park were regularly used for supply and fire control and occasionally for emergency landings. Six lookouts, supplemented by aerial observation, were actively manned for fire protection, and 14 cabins spread throughout the wilderness provided bases for trail crews, firefighters, and Fish and Game staff.

In that same year the Forest Service made a special management effort on the Big Prairie Ranger District (located entirely within the Bob Marshall Wilderness) to upgrade trails, manage the range resource for pack stock, irrigate pasture, build primitive camp facilities with pit latrines, replace worn out campsites, improve elk range, and increase fire control to keep fires down to 10 acres or less (California 1962).

The Bob Marshall was managed as a horse wilderness with outfitter camps occupied under special use permit. Although there was concern for the forage resource, limitations on animals per party were strictly voluntary, since outfitted-horse parties were considered the principal users of the wilderness. Little concern was given to other types of users. The idea of a segmented market or spectrum of activities and settings had not yet arrived.

Outfitters like old Joe Murphy of Murphy Flat had occupied the same heavily impacted campsites for more than 40 years. Garbage dumps were common. There were large fenced corrals for horses in some locations, an occasional primitive latrine and tent frames, and roughly "permanent" storage facilities for camping gear were not uncommon. In the fall, outfitter camps on the South Fork of the Flathead near Big Prairie looked like tent cities as Herb Toelke, Buff Hultman, and other elk hunters arrived.

Many of the outfitters were concerned mainly with fishing or hunting, but there were concerned naturalists like Hobnail Tom Edwards, a former teacher, who educated his parties about wilderness values. Edwards played a major role in creating the Scapegoat Wilderness to the south of the Bob Marshall, then known as the Lincoln Back Country.

There were among Forest Service personnel several old-timers whose careers were associated with the area. Addie Funk and Toad Paulin for years drove pack trains up and down the South Fork and did trail, cabin, and lookout maintenance in the wilderness. On the Sun River side, Pinnacle Paul Hazel was a legend at Beartop Lookout, and Phil Doughty was famous as a long-time mule skinner.

ORRRC STUDY

The Bob Marshall portion of the ORRRC national study of wilderness was done under my direction with the help of Robert W. Steele, fire ecologist at the University of Montana School of Forestry, and student assistant James Lambert. Steele did a fire study of the wilderness; Lambert and I did the user administration studies. W. Leslie Pengelly of the University of Montana did a wildlife study of the Danaher Basin that was separate from our efforts.

Besides the fire ecology and wildlife phases, the ORRRC study included interviews of wilderness visitors done in the summer and fall of 1960 and a descriptive report of use estimates, management problems, trends, and administrative cost estimates.

The study team covered most of the wilderness with backpack and horses. The Forest Service permitted us to use its wilderness cabins and food. Licensed outfitters and guides also helped us. Financial support came from a grant from the Wildland Research Center of the University of California and the University of Montana School of Forestry.

Access to the Bob Marshall was not as well developed in 1960 as it is today. At the north end on the South Fork of the Flathead River, the trail began at Spotted Bear Ranger Station, some 10 miles from the boundary at Meadow Creek (fig. 1). There was a short logging road up the Spotted Bear River for trail access; there was no paved airstrip at Benchmark, nor was there a road up Lodgepole Creek south of Youngs Pass. Access from Holland Lake was limited to one narrow trail.

We saw few people on the trails, even along the South Fork between Black Bear and Big Prairie. Since we wanted to contact people for interviews, seeing fresh horse droppings on the trail always raised our hopes.

Despite the lack of visitors, some people thought the area already was overused. Dr. Murphy, brother of the well-known outfitter Joe Murphy, told me the wilderness had been spoiled because you could then drive to within five miles of the boundary (Holland Lake). He first entered the area in 1908, traveling by horse from Missoula (more than 70 miles from the boundary).

All of the interviews were interesting. Mr. Johnson, chairman of Johnson's Wax of Racine, Wisconsin, visited the Wilderness in style, traveling with his Board of Directors and guide Howard Copenhaver. I interviewed him in camp at the mouth of Little Salmon Creek on the South Fork of the Flathead. He was primarily interested in fishing for big trout. He had selected the Bob Marshall over a grouse hunting trip to Ireland for this vacation/business trip. I was given 20 minutes prior to the afternoon board meeting.

Because of low use and the dispersal of visitors throughout the area and because we wanted information on the total wilderness, including lightly used parts, we obtained only 35 interviews. We did, however, collect useful information on standard questions used in ORRRC wilderness study areas throughout the United States. We asked respondents questions covering five topics: wilderness trip information, wilderness knowledge and interest, management, motivation for wilderness travel, and socio-economic characteristics. We mailed a post-trip questionnaire to field respondents as a followup (California 1962).

Given the small visitor sample in the Bob Marshall Wilderness, results were not significant statistically. There had been no previous formal studies of Bob Marshall visitors, however, so the results were of use for information purposes. They indicated a predominant use by horse parties, 94 percent of the total sample (table 1), with fishing a major activity in summer and hunting in fall. Visitors suggested the idea of a limited fee to preserve wilderness. They were moderately interested in wilderness legislation. Only 3 percent of the respondents indicated they would use the Bob Marshall for boating, rafting, or canoeing. More than 35 percent of the respondents were with outfitters in the summer; in the fall, more than 50 percent were.

Sixty-five percent of the interviewees were aware that the Forest Service was the agency responsible for the area. Although respondents were overwhelmingly in favor of wilderness preservation, a large percentage (43 percent) were unaware of proposed national wilderness legislation, and only 37 percent preferred a federal law to protect wilderness. They were generally opposed to resource use (timber cutting, mining, etc.) and to the development of facilities in the Bob Marshall. Use of the area was estimated at 5,350 visitors; the ORRRC growth prediction was for a 277-percent increase between 1959 and 1976. (California 1962).

THESIS STUDY

My major research effort in my doctoral study was a socio-economic analysis of the wilderness in the base year 1960. For this economic analysis of resource uses, I compared dispersed recreation under wilderness reservation with developed recreation and hypothetical timber production under full development. For study purposes, other national forest uses, including water, wildlife, and range, were assumed to be neutral. Two conjectural timber sales, evolved by using Forest Service appraisal methods, proved uneconomic. In terms of least public cost, the study showed that in 1960 the public interest was best served by reserving the Bob Marshall area as wilderness (Merriam 1964).

1964 STUDY AND FLOOD

In the summer of 1964, before passage of the Wilderness Act, we conducted a visitor interview study in the Bob Marshall, as well as in Glacier National Park and the Mission Mountains. Although it was a simple study, we found that different groups of visitors perceived their wilderness boundary in different ways, which suggested user categories based on desired trip objectives. At that time the Bob Marshall was viewed as providing undeveloped country with minimum technological modification and as more primitive than Glacier park or the Mission Mountains (Merriam and others 1968).

In June of 1964 there was a major flood that affected all the drainages in the Bob Marshall. Damage was greatest on the Sun River (Missouri River) watershed, but there also was much trail damage on the western slope (Columbia River drainage), particularly in the White River Basin. The Forest Service quickly initiated an intensive reconstruction program, employing helicopters, small trail tractors, and other equipment to make the

area accessible and safe. Although the agency apparently wanted to clean up the area before Wilderness Act limitations were imposed, the concept of adapting to the forces of nature seems to have been overlooked. With the passage of that act in September, the Bob Marshall was brought into the National Wilderness Preservation system.

WILDERNESS ACT PLANNING

To meet the conditions implied by the Wilderness Act, the Forest Service developed a management plan for the Bob Marshall (USDA Forest Service 1972). It addressed concerns for resources, wilderness protection, and administration. Specifically: The number of outfitter camps was to be limited to resource capabilities, permanent structures were to be removed, and parties were to be limited to a maximum of 14 days use per campsite. By 1974, commercial outfitter parties were to be limited to a maximum of 35 head of stock (one pack animal for two persons in summer use). The maximum number of guests in commercial parties was to be 15 by 1974 (table 1). Lookouts were to be phased out and the role of fire as a natural force was to be studied. No public aircraft landings were to be permitted, and airfields would no longer be maintained. Cross-country hiking was to be encouraged, with no new trails constructed without an approved plan. Under the assumption that use would increase, fire-use permits were to be required if such control were found appropriate to protect wilderness values (USDA Forest Service 1972).

CHANGES SINCE 1960

Members of my family, Bob Steele, and I visited the wilderness again in the summers of 1965, 1970-72, 1975, 1979, 1981, and 1984. A number of important studies of the Bob Marshall and its users were conducted in the intervening years. Many of the findings from these studies are relevant to this discussion.

We observed more use and more use changes each time we visited. By 1970, a second trail had been built from Holland Lake (south side); it offered trail-head packing and horse facilities. Always there seemed to be more horses and more backpackers, although evidence of large outfitter camps had been reduced and attempts at campsite restoration had been made.

In 1969 and 1970, researchers from the Forest Service Intermountain Forest and Range Experiment Station Wilderness Management Research Unit in Missoula, Montana, studied visitor use patterns, perceptions, and preferences for the Bob Marshall and other wilderness areas. The first study done by George H. Stankey, indicated that most visitors desired low intensities of use with few encounters. Hikers preferred not to meet horse parties, particularly large parties. Users defined some areas as crowded (e.g., the South Fork of the Flathead River and the Gates Park vicinity on the Sun River)(Stankey 1973). Robert C. Lucas included the Bob Marshall in a 1970 baseline study of use and users. He found that summer use of the area was greater than fall use. Although people were generally satisfied with their visit, 37 percent of Bob Marshall visitors thought the quality of the area had decreased (Lucas 1980).

In 1971 the road up the South Fork of the Flathead was extended to Meadow Creek (with a parking area and a horse ramp), less than one mile from the wilderness boundary. This provided easier access on a water grade into the Bob Marshall and increased use. By 1971 a paved airstrip had been built near the trail head at Benchmark. In 1972 we saw, for the first time, floaters on the South Fork of the Flathead and witnessed the competition for campsites along the shore.

During our 1975 visit, we again saw floaters and land-based campers along the South Fork of the Flathead and we noted congestion in the Black Bear vicinity. On a 1979 trip, Bob Steele and I were overtaken on the Monture-Hahn Creek trail by a jogger from a floater party. We saw the river floater outfitter operation, where parties were launched at the confluence of Young and Danaher Creek (at the head of the South Fork of the Flathead). We noted that river campsites showed the impact of continuous use (Merriam and others 1980).

In 1981, David N. Cole and assistants studied campsite conditions in the Bob Marshall Wilderness. He reported heavy impacts on campsites used by large parties with stock, particularly on the South Fork of the Flathead (Cole 1982).

Also in 1981, Bob Steele and I traveled from Benchmark up to the North Fork of the Sun River during a period of controversy over possible oil-gas exploration. We could hear helicopters over the ridge next to us. We saw persons on horseback going from Benchmark campground into the West Fork Licks. We saw no one on the North Fork trail, but there was considerable evidence of campsite occupancy and we saw people on trails near Pretty Prairie.

In 1982, Lucas continued his wilderness baseline study of the Bob Marshall Wilderness and the two contiguous areas in the complex. Results of the study revealed that use had increased some 60 percent from 1970 to 1982 and that there had been a shift from predominantly horse use (1970) to more hiker use. Parties were smaller with shorter stays (5.5 days average); fewer parties used outfitters. Visitors appeared to be better informed on packing out garbage than visitors in 1970 had been. There was more summer than fall use and only 22 percent of the visitors to the Bob Marshall complex had any contact with the Forest Service. Out-of-state use had increased to 43 percent. Although there was heavy use along the South Fork of the Flathead River in the river floater area, some areas had very light use (Lucas, in press).

Our 1984 trip took us from Holland Lake to the Gordon Pass and old Holland lookout areas. Here

we observed the heavy use entry point for the Bob Marshall. We noted three particularly interesting developments: 1) Many hikers were going to the Koessler-Doctor Lake area in the Swan Range -- an area little used in 1960 -- for fishing and enjoying the country. 2) Horse parties and pack outfits, some very poorly rigged, passed almost hourly. 3) Backpacker groups appeared to have little knowledge of the several routes to the South Fork of the Flathead, although they had good maps. None indicated any contact with Forest Service officers or staff.

In 1984 the Forest Service was developing a Flathead Wild and Scenic River Management Plan and had much river floater information from a series of studies done by W. J. McLaughlin and others from the University of Idaho (USDA Forest Service, 1984 draft). A majority of the rafters (52 percent) on the Upper South Fork Unit (Bob Marshall Wilderness) were from Montana. Nearly all used some outfitter services. Since outfitters must have a permit from the Forest Service, and there were at that time only five outfitters who did, some outfitting apparently was being done without permits.

McLaughlin reported floater tolerance for seeing others reportedly is low (50 percent preferred to see no one else on the river, shore, or takeout point). Since there are some 187 campsites along the upper South Fork, there is a good possibility of floater-shore user interaction. Fishing is a primary activity for both land-based users and floaters, another possible source of conflict.

CURRENT MANAGEMENT

The Forest Service management direction for the Bob Marshall, Great Bear, and Scapegoat Wilderness areas indicates concern for the number of outfitters, for problems related to visitor and agency resource use, and for the influence of such developments as oil and gas leases on the Sun River portion of the Bob Marshall (USDA Forest Service 1983). A major concern is carrying capacity, which has been included in the limits of acceptable change (LAC) system directed by Stankey and others (Keefe 1984).

The LAC system involves a nine-step process for coping with recreational demands on the wilderness. The process includes not only Forest Service managers and researchers, but also individuals representing organized and unorganized interests. Facilitation in the Bob Marshall complex is done by a contracted consultant who brings different interest groups into the process (Stankey and others 1984). Many think the process will be effective because conditions are dealt with in a precise, measurable way and because many concerned interests are involved. It is unclear, however, whether the diverse non-Montana concerns for this national wilderness resource will be adequately represented.

IMPLICATIONS

Table 1 indicates several important changes in Bob Marshall Wilderness use and management direction since 1960. Use, though now leveling off (Lucas, in press), has increased about as the ORRRC wilderness study predicted. Hiking may become the predominant use, with increases in river floating. Summer is apparently the major use season.

Outfitter use has declined and a new breed of outfitter has replaced old-timers like Joe Murphy and Hobnail Tom Edwards. The Forest Service has imposed controls on outfitted parties that regulate length of stay, number of stock, and party size. There are still major campsite use impacts, and the South Fork of the Flathead River seems to be a major point for conflict with horse users, hikers, and floaters. Out-of-state use has increased to become a major component of visitations.

Over the years, managers have reduced facilities to conform to the directions of the Wilderness Act. Lookouts, airfields, and cabins have been reduced in number. Adaptations are being made to minimize user impact within acceptable limits. The Forest Service is more concerned than it was in 1960 with planned and coordinated management of the expanded Bob Marshall Wilderness. Yet the Bob Marshall is more readily accessible by road than it was in 1960, the adjoining area is more developed, and few people, including out-of-state visitors, contact the Forest Service for information.

What type of first summer hiking wilderness experience would a person in their mid-twenties --someone like Jim Lambert, student assistant in the 1960 ORRRC study, for example--be likely to have in the Bob Marshall today? First, he could drive to Meadow Creek on the South Fork of the Flathead River, reducing the 1960 trip by 10 miles. Also, he could reduce his entrance mileage on the Spotted Bear River by driving almost to Limestone Cabin. Continuing up the South Fork, he probably would see several other parties each day, mostly horse parties (McCool and others 1984). He might have difficulty finding a campsite that offered solitude in the Black Bear to Big Prairie area, and if he camped by the river he would be likely to see floaters.

Although his equipment would be superior to what was available in 1960, the trails he would travel probably would not be in as good condition. If he camped near the mouth of the Little Salmon and the South Fork, he would not find visitors like Mr. Johnson. The old site has been restored and closed to stock. Probably the wealthy big trout fishermen are seeking less frequented haunts in Alaska or overseas.

The changes that have occurred since 1960 can be attributed in part to the increased interest in physical fitness (e.g., walking and backpacking) that grew out of the environmental movement of

the 1970s and has been heightened by improvements in camping equipment. The publicity attending the Wilderness Act of 1964 undoubtedly has drawn people to notable areas like the Bob Marshall (as has happened in Minnesota's Boundary Waters Canoe Area).

Probably there will be considerable change in the next 25 years. From a research standpoint, continued studies of user trends could be useful, particularly if they were directed toward optimum wilderness use as it relates to interactions between users (e.g., horse users, hikers, and floaters). Studies of effective visitor information systems and user management are in order. Good coordination of research and management efforts is essential.

Management might well consider ways to zone the South Fork to reduce conflict and increase solitude (e.g., keep horse parties back from the river campsites or limit the number of rafters who can enter the South Fork per week). Limitations on fishing might be needed to protect the fishery.

Visitor contact with the Forest Service, especially for out-of-state users, could be encouraged outside the wilderness at ranger stations through signs, radio spot announcements, travel agencies, etc. Trail-head information maps and signs could be helpful in orienting first-time visitors.

Now that there are three wilderness areas in this complex, it is possible that over the years it will be necessary to use entry permits as a monitoring and control device (similar, perhaps, to the Boundary Waters Canoe Area Wilderness permit system in the Superior National Forest).

As Dr. Murphy said in 1960, the wilderness has changed. There is less development in the area by and for visitors. There is more use and a greater probability of user conflict. The use and popularity of the Bob Marshall have extended well beyond Montana.

Every new visitor sees the wilderness in their own way. We must remember that, although the basic resource changes very slowly and we are only visitors, our impact on the land and other users remains.

REFERENCES

California, University of. Wildland Research Center. Wilderness and recreation - A report on resource values and problems. Outdoor Recreation Resources Review Commission Study Report 3. Washington, D.C.: U.S. Government Printing Office; 1962. 352 p.

Cole, David N. Campsite conditions in the Bob Marshall Wilderness, Montana. Research Paper INT-312. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 18 p.

Keefe, Ken (Letter to author). 1984 September 4.

Lewis, D. H. Regional agricultural report, upper South Fork Flathead River. 1915. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Big Prairie Guard Station. Flathead National Forest, Montana.

Lucas, Robert C. Use patterns and visitor characteristics, attitudes and preferences in nine wilderness and other roadless areas. Research Paper INT-253. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 89 p.

Lucas, Robert C. Use patterns, visitor characteristics and attitudes in the Bob Marshall Wilderness complex - 1970-1982. Research Paper. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station (in press).

McCool, Stephen F.; Ashor, Joseph L. Draft plan III for determining limits of acceptable change for the Bob Marshall, Scapegoat, and Great Bear Wilderness (Steps 1-6) 1984. Unpublished draft supplied to author by Stephen F. McCool.

Merriam L. C., Jr. The Bob Marshall Wilderness Area of Montana, a study in land use. Corvallis, OR: Oregon State University; 1963. 222 p. Ph.D. dissertation.

Merriam, L. C., Jr. The Bob Marshall Wilderness Area of Montana, some socio-economic considerations. Journal of Forestry 62(11):789-795; 1964.

Merriam, L. C., Jr.; Ammons, R. B. Wilderness users and management in three Montana areas. Journal of Forestry 66(5):390-395; 1968.

Merriam, L. C.; Steele, R. W. Bob Marshall Wilderness: A reminiscence. Western Wildlands 6(2): 23-24; 1980.

Stankey, George H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 61 p.

Stankey, George H.; Cole, David N.; Lucas, Robert C. (and others). The limits of acceptable change (LAC) system for wilderness planning. General Technical Report INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

USDA, Forest Service. Bob Marshall Wilderness area. Washington, DC: USDA-Forest Service; 1940, 15 p.

USDA, Forest Service. Bob Marshall Wilderness plan. Missoula, MT: USDA-FS. Northern Regional Office; 1972. 52 p.

USDA, Forest Service. Bob Marshall, Great Bear, Scapegoat wilderness management direction, Appendix 0-2. Review draft. Montana: USDA-FS, Flathead, Helena, Lewis and Clark national Forests, Montana; 1983. 30 p.

U.S. Department of Agriculture, Forest Service, Flathead National Forest; U.S. Department of the Interior Park Service, Glacier National Park. Draft Flathead Wild and Scenic River management plan supplement. Kalispell, Montana: U.S. Department of Agriculture, Forest Servicce, Flathead National Forest; 1984. 128 p.

INFLUENCE OF VISITOR EXPERIENCE ON WILDERNESS RECREATION TRENDS

Robert C. Lucas

ABSTRACT: Many changes in use and users in the Bob Marshall Wilderness complex from 1970 to 1982 are associated with changes in visitor experience types. Experienced wilderness visitors who were newcomers to the Bob Marshall increased most, and had use characteristics linked to most major changes. Experienced newcomers, beginners, and veterans all differed in many ways. Implications for management and research are presented.

INTRODUCTION

A comprehensive 1970 survey of visitors to the Bob Marshall, Great Bear, and Scapegoat Wildernesses in Montana was repeated in 1982 (Lucas 1985). To my knowledge, it is almost the only study of this type. Most other trend studies of wilderness recreation have measured relatively few characteristics and covered short periods ranging from 1 to 5 years (Lucas 1967; Cieslinski 1980; Corti and others 1982; van Wagtendonk 1981). The most similar study is a comparison of a number of use and user characteristics for the Great Smoky Mountains National Park backcountry for 1973 and 1983 (Burde and Curran in press).

From 1970 to 1982, the three-area Bob Marshall Wilderness complex experienced a number of major changes in types of use, use patterns, and the behavior, characteristics, and attitudes of users, against a background of considerable stability (Lucas 1985). There are many possible factors associated with these changes, but prior wilderness experience of visitors, and changes in that experience, are related to many of the trends. The two objectives of this paper are to describe the relationship of major trends in use/user characteristics to visitor experience, and to identify management implications of the relationship.

Visitors' prior recreational experience is a powerful factor influencing recreation behavior. Each visitor's history of experience forms a frame of reference for personal evaluation of specific settings and recreation engagements (Schreyer 1982). Each recreationist's experience history is complex, involving amount, type, and location of prior participation, and often representing commitment to a type of recreation and specialization in style of use, for example, the dedicated dry fly fisherman (Bryan 1977). However, for analysis, simplification and classification of experience history are needed. Until recently researchers usually just employed measures of either experience at the specific recreation site, or experience in a general type of activity. Several recent studies (Hammitt and McDonald 1983; Schreyer and Lime 1984; Schreyer and others 1984) have combined several measures of experience into typologies. This is similar to the approach used in this study of the Bob Marshall Wilderness complex.

METHODS

Study Area

The three-wilderness complex consists of the Bob Marshall Wilderness (1,009,000 acres), north of it the Great Bear Wilderness (287,000 acres), and south and east of the Bob Marshall, the Scapegoat Wilderness (239,000 acres) (fig. 1).

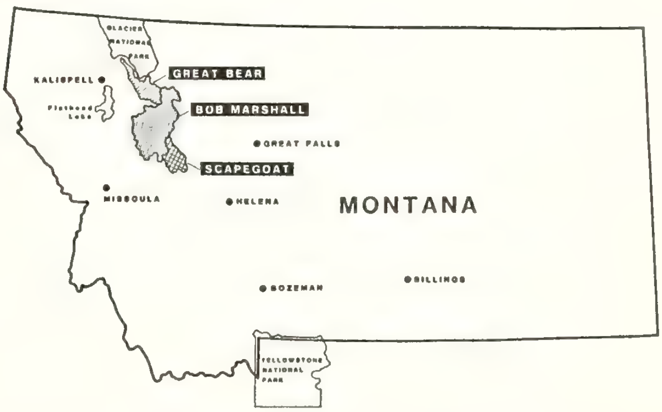

Figure 1.--Location of the Bob Marshall, Great Bear, and Scapegoat Wildernesses.

The complex is managed by four National Forests. The area is south of Glacier National Park and is located on both sides of the Continental Divide. There are high, rugged mountains up to about 9,000 feet elevation and major river valleys--particularly the Middle and South Forks of the Flathead River, the Sun River, and the

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North Fork of the Blackfoot River. Most of the area is steep and forested, with a moderate number of lakes, most in glaciated cirques. Elk, deer, black and grizzly bears, mountain goats, moose, and bighorn sheep are all present. There are about 70 trailheads providing access to the area, all of which were in use both study years.

Study Period

The main visitor use season was studied both years, from June 18 through November 20 in 1970, and from June 21 through October 25 in 1982. Use in November was very light (less than 4 percent of the total in 1970), and the differing ending dates do not affect comparability appreciably.

Sampling

Visitors entering or leaving were contacted at randomly selected sample trails and dates by field workers who explained the study and asked for names and addresses. The design involved cluster sampling of trailheads and dates, with questionnaires mailed to a subsample of visitors from each trailhead/date cluster. Procedures were similar both years; see Lucas (1985) for sample design details. All individuals at least 16 years old were sampled, except those making very brief visits, less than 3 hours long, who were excluded. There were no refusals to cooperate in 1970, and only one in 1982. In 1970, with up to four followup mailings, 502 mail questionnaires were completed and returned, a 91 percent rate; and in 1982, with up to two followup mailings, 746 were returned, for an 82 percent rate (compared to 86 percent in 1970 after two followups). This constituted about a 3.5 percent sample of visitors in each year. Using special temporary registration stations, visitors to very lightly used trails were oversampled in 1982, and were weighted fractionally to yield a weighted sample total of 531.

Questionnaire

A fairly long, comprehensive questionnaire was used. The 1982 questionnaire was 17 pages long, a little longer than in 1970, which, together with fewer followups, probably resulted in the slightly lower rate of return in 1982 than in 1970. The questionnaire covered activities, route of travel, camping practices, encounters, satisfaction, attitudes and preferences, and personal and group characteristics. The same basic questionnaire was used both years, with very few changes in 1982.

Experience Classification

Two variables were combined in the experience classification: (1) general wilderness experience, defined as whether the person had visited any wilderness before; and (2) site-specific experience, whether the person had previously visited the Bob Marshall Wilderness complex. The resulting three types were:

1. Beginners--people on their first trip to any wilderness.

2. Experienced newcomers--people who had visited other wildernesses, but who were visiting the Bob Marshall Wilderness complex for the first time.

3. Veterans--people who had visited the Bob Marshall Wilderness complex before.

Data are available on the number of previous visits to the Bob Marshall Wilderness complex, although general experience was measured only in yes-no terms. Persons who had any previous visits to the Bob Marshall Wilderness complex were classified as veterans. It would be possible to subdivide the veterans into several degrees of prior experience, although for simplicity this has not been done. In fact, most veterans are quite experienced, so the practical effect of shifting definitions would not be great. Both years, only 22 percent of the veterans had made just one earlier visit; the mean number of previous visits was seven in 1982, 10 in 1970. The average length of stay in the Bob Marshall complex both years was about 5 days, so even one or two previous visits represent considerable experience.

FINDINGS

Changes in Experience

In 1970 a majority of the visitors had been in the area before (table 1). In 1982 this was not the case. Experienced newcomers accounted for a larger proportion of visitors in 1982 and veterans a smaller proportion than in 1970. The change was an exact trade-off; the proportion of beginners was the same both years, 22 percent.

Table 1.--Distribution of experience types, 1970 and 1982

Year	Beginners	Experienced newcomers	Veterans
	Percent of total visits		
1970	22	23	55
1982	22	33	45

$X^2 = 14.6$, 2 df, $p < 0.001$

Official use estimates for the Bob Marshall complex indicate at least a 60 percent increase in total recreational use from 1970 to 1982 (Lucas 1985). On this basis, the proportional shifts in table 1 represent increases in actual numbers

of visits by each experience type of 60 percent for beginners, 130 percent for experienced newcomers, and 31 percent for veterans. The number of experienced wilderness travelers coming to the Bob Marshall complex for the first time has clearly grown substantially.

The increase in this experience type is associated with a number of changes in types of use, visitor attitudes, and visitor characteristics. These changes are apparently not due to differences in ages among experience types. All three experience types averaged 33 to 34 years of age in 1982 (although the experienced newcomers were somewhat younger than other types in 1970). Thus, it appears the differences among experience types reflect differences in knowledge, skills, interests, and values rather than age.

Major Change--From Horse Use to Hiking

In 1970, people using horses outnumbered hikers about three to two. In 1982, the proportions were just reversed. This shift is thought to be occurring in a number of wildernesses, but I am not aware of any data documenting this trend. The large influx of experienced newcomers accounts for a substantial part of this shift; this experience type consisted largely of hikers, as shown below:

Percent of total visits by hikers for each experience type

	1982	1970
Beginners	54	29
Experienced newcomers	78	43
Veterans	54	40

In 1970 the experienced newcomers were most often hikers, but the difference was small. The trend toward backpacking has affected this experience type most strongly.

Attitude Changes Show Two Problems Growing

Two major problems intensified from 1970 to 1982 in the opinion of visitors: horse-hiker conflict and trail conditions. There is an association in both of these cases with the shift to more hiking use, but experience types also are strongly associated with the horse-hiker conflict, more so than method of travel.

Although a majority of all three experience types are hikers, in 1982 volunteered complaints about horses and their effects were far more common from experienced newcomers. They were twice as likely as veterans to list "too many horses" as reducing satisfaction and four times as likely as beginners, at 12 percent compared to 6 and 3, respectively. Eight percent of the newcomers mentioned "horse manure" as decreasing satisfaction, compared to only 3 percent of the veterans and 1 percent of the beginners.

The more intense reaction to horse use by experienced newcomers is not explained by a greater sensitivity to crowding in general. Although they did attach greater importance to solitude as a reason for visiting wilderness, they complained of crowding about the same as veterans, while beginners complained much less. Standards for desired campsite solitude were about the same for all experience types, with beginners slightly more willing to accept neighboring campers. Thus, it appears that conflict, or one-way resentment, is really the problem more than crowding.

Trail condition complaints were six times as common in 1982 as in 1970. In this case, the veterans complained the most, beginners the least. Beginners complained much more about inadequate directional signs than did newcomers, although neither type had ever been in the Bob Marshall complex before. Apparently the newcomers had developed more map-reading skills than beginners, and perhaps also a preference for fewer man-made features in wilderness. The veterans rarely mentioned signs as a problem, probably mainly due to familiarity with the lay of the land.

Impact Potential Declined

A number of changes from 1970 to 1982 suggest a reduced per-party potential for adverse impacts on resources and visitor experiences.

First, parties became smaller, with an average of 4.3 persons in 1982 compared to 4.9 in 1970. Newcomers and veterans were very similar in party size in 1982, averaging 4.2 and 4.5 persons, respectively (a nonsignificant difference), and with only 7 and 9 percent of total visits made by parties with 10 or more members. Beginners were in larger parties, averaging six persons (significantly different from newcomers and veterans at $p < 0.05$), and 22 percent with 10 or more. This pattern also existed in 1970. Five percent of beginner parties were in violation of a regulation setting 15 as the maximum permissible size, while 2 percent of the veterans were over the size limit and less than 1 percent of the newcomers. It is clear that large parties detract from other visitors' experience (Stankey 1973), and probably have disproportionate resource impacts (Cole 1981).

Second, campfire impacts were reduced. Campfires have a high potential for impact both from the fire itself and from gathering fuel (Cole and Dalle-Molle 1982). This potential impact by typical parties declined as use of portable campstoves increased and dependence on wood fires declined from 1970 to 1982. In 1970, 73 percent of the campers used only campfires, while others had stoves, often in combination with occasional campfires. In 1982, just 51

percent used only campfires; the remainder had stoves. The experienced newcomers were by far the most likely to use stoves in 1982, with 61 percent doing so, compared to 43 percent of the veterans, and only 33 percent of the beginners. (All differences significant at $p < 0.05$.) Similar differences among experience types existed in 1970, but differences were smaller. Experienced newcomers have adopted campstoves much more than other experience types.

Third, fewer visitors had horses in 1982, particularly the newcomers, as described above, which reduces per-party pressures because horses can potentially cause substantial impacts (Cole 1983).

Fourth, visitors' knowledge of minimum-impact use techniques, which is critical for reducing impacts, improved. "Pack-it-in, pack-it-out" is one of the important recommended practices. In 1970, 56 percent of the visitors said "burying unburnable garbage" was desirable (the wrong answer). In 1982, only 31 percent still gave the wrong answer. Both newcomers and veterans are reasonably well informed; only 27 percent gave the wrong answer in 1982. Half of the beginners, however, are misinformed on how to handle garbage, which is only slightly better than the overall knowledge level in 1970. Differences among experience types in knowledge were small in 1970, indicating that learning has been limited to newcomers and veterans.

Fifth, use in 1982 was somewhat less consumptive and more contemplative, as the proportion of visitors hunting and fishing declined (fishing to a lesser extent) and photography, nature study, and swimming increased. The newcomers did the least fishing and hunting in 1982, and the veterans the most, which was also true in 1970.

Sixth, the timing of use evened out. Weekend peaks in visitor entries were less pronounced in 1982 than in 1970. The experienced newcomers had the most weekday use compared to weekends, and veterans the least.

Finally, use became more evenly distributed. Use of trailheads was less concentrated in 1982 than in 1970. The beginners were most concentrated at a few trailheads, the veterans least concentrated, and the experienced newcomers were intermediate in use concentration. This dispersal probably reduces some impacts, but may spread others.

The aggregate effect of all these changes reduces visitor impact potential substantially. The experienced newcomers contribute to all of the changes, usually strongly, with a relatively low impact style of use.

Other Changes

Visitor education levels were very high both years, but higher in 1982 than in 1970. The experienced newcomers had the highest education levels both years. In 1982, 57 percent were college graduates. Veterans had the lowest education levels, but still high (41 percent college graduates in 1982), while beginners were intermediate.

More visitors came from outside Montana in 1982 than in 1970. The three experience types varied widely in their place of residence: in 1982 more than three-fourths of the veterans were Montanans; but only 38 percent of the beginners were Montana residents. Half of the newcomers were Montanans. Patterns in 1970 were similar.

A greater proportion of visitors were women in 1982 than in 1970, 30 percent compared to 20 percent. This was a general change, as experience types varied little, but the proportion of women in veteran groups rose the most (it was the lowest in 1970).

Visitors with professional-technical occupations were most common both years, and were a larger proportion of the total in 1982 than in 1970. Half of the newcomers in 1982 worked in professional and technical occupations, compared to about one-third of the other two experience types. This pattern also can be seen in the 1970 data.

The change in fire policies to permit natural lightning fires to more nearly play their natural role developed largely in the 1970's, and visitor support for this natural fire policy change grew substantially from 1970 to 1982. More beginners rejected natural fires than accepted them, while close to twice as many experienced newcomers and veterans accepted fire's natural role as rejected it. Newcomers were most supportive, although few were hunters who would probably benefit most from more fires through improvement of elk habitat.

In general, visitors in 1982 were less supportive of facilities such as fireplaces, picnic tables, and outhouses, or more "purist," than in 1970. (Trails and bridges over large, dangerous rivers were an exception; support for these facilities increased.) The beginners were by far the least purist on facilities both years, while the veterans were most purist, a bit more so than the experienced newcomers.

Summer accounted for a greater proportion of use in 1982 than in 1970, and the experienced newcomers had the highest concentration of use in the summer both years.

The proportion of visitors traveling with outfitters declined from 1970 to 1982. In 1982 the newcomers used outfitter services the least (10 percent), veterans next (19 percent), and beginners by far the most (41 percent); this was also the pattern in 1970.

Most visitors said they wanted no other parties camped within sight and sound both years, but a few more preferred company in 1982 than in 1970. Experience types account for little of this trend; beginners were only slightly more likely to prefer other campers nearby than the other two types.

Membership in wilderness-oriented clubs dropped from 1970 to 1982, but experience types varied little in club affiliation.

Many Factors Did Not Change

Overall satisfaction levels remained high. The beginners, however, were better satisfied than the experienced newcomers or veterans both years, but especially so in 1982, as newcomers and veterans became more discriminating. Beginners also rated impact conditions much better than other experience types both years, and reported meeting too many other visitors less often, especially in 1982. Differences among experience types in norms for acceptable wilderness conditions appear to be the main cause for these variations in evaluations of the area.

Solitude was still an important motive for visitors. Both years newcomers attached the most importance to solitude and beginners the least, again apparently due to different norms.

About two-thirds of all visitors were from urban areas both years. The veterans were most rural both years, the beginners most often from large cities (especially in 1982), and the newcomers intermediate.

Most visitors did not contact the Forest Service for information. In 1982 only 12 percent of the veterans did, less than half the rate for newcomers (32 percent) or beginners (27 percent). Apparently, the veterans' familiarity with the area reduces their desire for more information. The newcomers seldom use outfitters, unlike the beginners, and therefore need information more, and their general experience probably makes them more aware of types of important information to seek.

The proportion of different types of social groups was unchanged over the period, but experience types varied in 1982, although little in 1970. Veterans had the highest proportion of family groups, beginners the lowest. Newcomers had the highest proportion of groups of friends (peer groups), veterans the lowest, which may contribute to the greater mobility among wildernesses by the newcomers.

There was no appreciable shift in age distributions; half of all visitors were 25 to 44 years of age both years. As pointed out before, all experience types averaged 33 to 34 years of age. Age distributions varied a little both years, however, with newcomers most concentrated in the 25 to 44 bracket, and least numerous in the 14 and under class, while the veterans had the most visitors 14 and under, consistent with their high proportion of family groups.

The personal importance visitors assigned to wilderness was high both years, with just a slight decline from 1970 to 1982. Beginners rated wilderness less important than newcomers and veterans both years, presumably because many had not yet developed deep personal commitment. Some will never visit a wilderness again.

Support and opposition to most existing or potential regulations changed little between the 2 years. Experience types varied considerably, however. Both years veterans were most opposed to almost all regulations, and experienced newcomers most supportive.

SUMMARY OF FINDINGS

One-third of 1982 visitors to the Bob Marshall Wilderness complex were experienced newcomers, up from 1970. They reflect many of the changes from 1970 to 1982. They are mainly summer backpackers, are most bothered by horse users and their impacts, are most critical of impact conditions, accept existing and potential regulations the most, seek solitude the most, depend least on wood fires, hunt least, use outfitters least, have the highest education levels, highest proportion in professional-technical occupations, and most often contact the Forest Service for information. Most of the characteristics persisted from 1970 to 1982, but some reflect general changes that affected this experience type more than others, especially the beginners.

The beginners accounted for 22 percent of the visitors in both years. Almost half of them used horses, they had the largest groups, and most of the groups violating the 15-person limit. They were most likely to use an outfitter's service, were most concentrated at a few trailheads, depended on wood fires the most, were most often from large cities, attached the least importance to wilderness, were least concerned with solitude, complained least about crowding or conflict, were by far the best satisfied, rated impact conditions best, knew the least about minimum-impact camping, supported a natural fire policy least, were least purist in support or opposition of most facilities, and were most often from out of State. They changed the least from 1970 to 1982 of any of the experience types.

The veterans dropped from 55 to 45 percent of all visitors from 1970 to 1982. They were also almost half horse users, had the greatest proportion of fall use, fished and hunted most, complained most about trails, opposed regulations most, were most purist in opposing facilities (by a narrow margin over experienced newcomers), contacted the Forest Service least, had the most family groups and the most children but fewest women, were most rural, and most often from Montana. Most of these characteristics carried through from 1970 to 1982.

MANAGEMENT IMPLICATIONS

All first-time visitors to the Bob Marshall Wilderness complex are not the same. As Schreyer and Lime (1984) observed in a different setting, a novice is not necessarily a novice. The experienced newcomers in this study are very different from the beginners, although none of them had been in the area before. They present an entirely different situation for managers. Lumping all first-timers together would result in a confused picture of who these visitors are and what challenges and opportunities they represent.

The beginners pose several problems for managers. They have the highest potential for impact because they are often in large parties, with horses, concentrated on a few main trails, depend on wood campfires, and are not well informed about wilderness, wilderness philosophy, or minimum-impact methods. Most of them live in other States, often far away, making many kinds of communication difficult. On the positive side, over one-fourth contact the Forest Service on their own, seeking information. These contacts need to be given high priority and used effectively to help inform and educate the beginners. Furthermore, over 40 percent of the beginners travel with outfitters. Probably much of what they know about wilderness they have learned from outfitters and their crews. Managers should work with outfitters to help educate neophytes so they can enjoy the wilderness more and impact it less, which would benefit the outfitters, their guests, other visitors, and the wilderness managers, as well as the wilderness resource itself.

The veterans present a different challenge. They are better informed and have lower potential impacts than the beginners. Improving their camping practices further is inhibited by their very limited voluntary contact with the managing agency. They are most resistant to regulations; if new regulations become essential, explaining the need for them to the veterans will be particularly necessary. Most of the veterans live nearby; information programs in local communities can reach many of them.

The experienced newcomers present still a different task for managers. They seem to bring a set of expectations and norms from their experiences in other wildernesses to the Bob Marshall Wilderness complex that sometimes lead to difficulty accepting the substantial horse use they encounter. The managers' challenge is to use education to help these newcomers, overwhelmingly backpackers, to develop more realistic expectations and thus reduce dissonance between expectations and experiences. Information might also direct hikers with antipathy to horses to places where they would encounter fewer horses. Education to improve courtesy by all visitors might reduce conflicts also.

At an earlier time, the Bob Marshall Wilderness was almost entirely a horse travel wilderness. It was estimated in 1960 that over 90 percent of the visitors were on saddle horses (ORRRC 1962). Now, the three-wilderness complex has more backpackers than riders. (The Bob Marshall itself still has a few more horsemen than hikers, and because horsemen stay considerably longer than hikers, they still account for a majority of the visitor-days of use.) Some of the backpackers object to the horsemen, and the potential for the succession from horse to hiker to proceed toward displacement of horse users should be a concern for managers. Loss of the opportunity for a horseback wilderness visit would narrow the range of experience opportunities in the wilderness system. Some type of zoning or identification of primary horse use areas might be worth considering.

Education efforts already mentioned are one approach to trying to avoid displacement. Correcting the serious problem of poor trail conditions has to be another part of any solution. Probably the main complaint of the hikers is trails churned to mud, which many blame on horse traffic. Better located, better drained trails are needed to reduce this source of conflict. It needs to be remembered, however, that bad trail conditions bother all experience types and horsemen as well as hikers, and trail improvements would benefit all visitors.

NEEDED RESEARCH

Concern has been expressed for years that visitor attitude and preference surveys can mislead managers because new people come to a wilderness with weakly developed expectations and thus will accept whatever they encounter, while more demanding visitors may leave as conditions change and thus no longer be represented in visitor surveys. This is a reflection of the succession-displacement process. The beginners here clearly exhibit uncritical acceptance of conditions they are encountering for the first time. However, the experienced newcomers are more demanding than the veterans on many attributes of wilderness, and similar on others. This type of experience analysis can deal with the concern that attitudes are distorted by latecomers. Other research needs to follow former visitors to learn their reasons for not returning, and the management implications of these reasons.

If recruitment of new wilderness recreationists slows down in the future, as seems possible, the experienced newcomer group is likely to become more common in many wildernesses. Research could investigate if this happens, and increase understanding of this type of visitor. Research might determine if many of these newcomers visit numerous different areas, which could have implications for consistency among wildernesses in management policies, recommended camping practices, and so on. The motivations for this shifting visitation also could have management

implications--how much is due to dissatisfaction, how much to seeking diversity, how much is "trophy collecting"?

Further research on experience as a factor in recreation use patterns, behavior, and attitude appears worthwhile. Various ways of conceptualizing and defining visitor experience history need to be developed and tested. For example, Schreyer and others (1984) classified river runners' experience histories into six types based on total number of river trips, number of rivers run, and number of trips on the study river. The earlier simple classifications based on only one type of experience (particularly visits to the study area) risk being seriously misleading. Some combination of general and area-specific experience captures much of the significance of previous experience. The classification used here seems to be useful both for increasing understanding of trends and for interpreting management implications.

In general, more longitudinal research on wilderness use and users is needed. One-time studies can identify situations, but managers are seriously hampered in assigning priorities to efforts to solve problems without trend data to indicate stable, improving, and worsening conditions. Researchers also can learn more about the processes of human use of wilderness from time-series studies.

REFERENCES

Bryan, Hobson. Leisure value systems and recreational specialization: the case of trout fishermen. Journal of Leisure Research. 9(3): 174-187; 1977.

Burde, John H.; Curran, Kevin A. User perception of backcountry management policies at Great Smoky Mountains National Park. In: Proceedings, symposium--wilderness and natural areas in the East: a management challenge; 1985 May 13-15; Nacogdoches, TX. Nacogdoches, TX: Stephen F. Austin State University, School of Forestry; [in press].

Cieslinski, Thomas J. Trends in Allagash Wilderness Waterway uses. In: Proceedings 1980 national outdoor recreation trends symposium; 1980 April 20-23; Durham, NH. Vol. II. General Technical Report NE-57. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1980: 147-149.

Cole, David N. Vegetational changes associated with recreational use and fire suppression in the Eagle Cap Wilderness, Oregon: some management implications. Biological Conservation. 20(4): 247-270; 1981.

Cole, David N. Campsite conditions in the Bob Marshall Wilderness, Montana. Research Paper INT-312. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 18 p.

Cole, David N.; Dalle-Molle, John. Managing campfire impacts in the backcountry. General Technical Report INT-135. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 16 p.

Corti, Adrienne; Petersen, Margaret E.; McCool, Stephen F. Trends in recreational use of the Rattlesnake National Recreation Area and Wilderness: a test of the designation hypothesis. 1982. Report submitted by the University of Montana to: Wilderness Management Research Unit, Intermountain Forest and Range Experiment Station, Missoula, MT. 11 p.

Hammitt, William E.; McDonald, C. D. Past onsite experience and its relationship to managing river recreation resources. Forest Science. 29(2): 262-266; 1983.

Lucas, Robert C. The changing recreational use of the Boundary Waters Canoe Area. Research Note NC-42. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1967. 4 p.

Lucas, Robert C. Wilderness use patterns, visitor characteristics, and attitudes in the Bob Marshall Wilderness complex, 1970-1982. Research Paper INT-345. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985. 32 p.

Outdoor Recreation Resources Review Commission [ORRRC]. Wilderness recreation--a report on resources, values and problems. Study Report 3. Washington, DC: U.S. Government Printing Office; 1962. 352 p.

Schreyer, Richard. Experience level affects expectations for recreation participation. In: Forest and river recreation: research update: selected papers presented at the symposium on leisure research, National Recreation and Park Association; 1981 October 25-27; Minneapolis, MN. Miscellaneous Publication 18. Minneapolis, MN: University of Minnesota, The Agricultural Experiment Station; 1982: 154-159.

Schreyer, Richard; Lime, David W. A novice isn't necessarily a novice--the influence of experience use history on subjective perceptions of recreation participation. Leisure Sciences. 6(2): 131-149; 1984.

Schreyer, Richard; Lime, David W.; Williams, Daniel R. Characterizing the influence of past experience on recreation behavior. Journal of Leisure Research. 16(1): 34-50; 1984.

Stankey, George H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 61 p.

van Wagtendonk, Jan W. The effect of use limits on backcountry visitation trends in Yosemite National Park. Leisure Sciences. 4(3): 311-323; 1981.

EXPERIENCE LEVEL AND PARTICIPATION MOTIVES OF

WINTER WILDERNESS USERS

William E. Hammitt, Cary D. McDonald, and Janet L. Hughes

ABSTRACT: Little wilderness research has been conducted on winter or off-season users. Investigated in this study were the use patterns, experience levels, and participation motives of winter backpackers in Great Smoky Mountains National Park (GSMNP). Use level of past experience was defined four different ways and tested for its effect on user motives for winter participation in backcountry camping. Results indicate that winter users of GSMNP engage in backcountry camping nearly twice as often during winter as other seasons, both in and outside the Park. They are experienced users, averaging 10 years, 6.7 trips, and 19 days per year, of backpacking experience. Major motives for winter wilderness use were to experience the winter environment and its quiet solitude. Analysis between experience level and motives for winter participation showed that only desire for solitude increased significantly ($p \leq 0.05$) with higher levels of past experience.

INTRODUCTION

Little wilderness and backcountry (wilderness and backcountry are used interchangeably in this paper) research has concentrated on off-season and, more specifically, winter users. For certain wilderness users this is the most popular season for backpacking (Hughes 1985). In many wilderness areas, as users become more experienced or as areas become more crowded, we can expect winter use to increase.

While there have been numerous use and management studies of summer backcountry campers (Merriam and Ammons 1968; Hendee and Catton 1968; Hendee and others 1968; Stankey 1973; Hendee 1974; Lime and Buchman 1974; Lucas 1974; Murray 1974; Stankey and others 1974; Lime 1976; Echelberger and Moeller 1977; Bratton and others 1978; Hendee and others 1978; Leonard and others 1978; Cannon and others 1979; Roggenbuck and others 1979; Boteler 1981; Lucas 1980; Roggenbuck 1980) few, if any, studies have focused on winter overnight use. As a result, wilderness recreation managers are limited to using peak season use information to manage off-season users. For the resource manager, a critical question becomes: are the use patterns, experience levels, and participation motives of winter wilderness campers similar enough to summer wilderness campers that the two can be managed in a similar manner?

Differences in the use patterns, experience levels, and motivational preferences of winter recreationists are important to several wilderness management issues. The safety of visitors in wilderness is always a management concern, but it is a particular concern during periods of severe weather, such as winter. Knowledge of visitor use patterns is crucial when safety and rescue missions are needed. Experience level of users is an important dimension of recreation specialization. With almost any recreational activity, as users become more experienced, they become more specialized in how and where they prefer to conduct that activity. Winter backpacking is one means of specializing in use of wilderness. Winter wilderness use is also a means of avoiding crowded situations that occur during peak-use summer months. Winter recreationists offer an important opportunity to examine certain aspects of displacement. These are a few of the many issues that relate to the need to examine winter wilderness use.

In two previous papers (Hammitt and Loy 1981; Hammitt and Hughes 1984), data indicated that the use patterns of winter and summer backcountry campers in Great Smoky Mountains National Park were different. Data from 580 winter and summer user permits in 1979 showed that party size was the only major use variable that did not differ ($\bar{x}$=2.6 and 2.7 persons per party, figure 1). Summarizing the differences between the two seasonal types of users, we found that nearly a third more winter campers started their hike on weekends; their length of stay was only about one-half as long; they hiked considerably less (18.3 miles for winter, 27.8 miles for summer users); they took more planned loop hikes (88 percent winter, 73 percent summer); and the percentage of hikers

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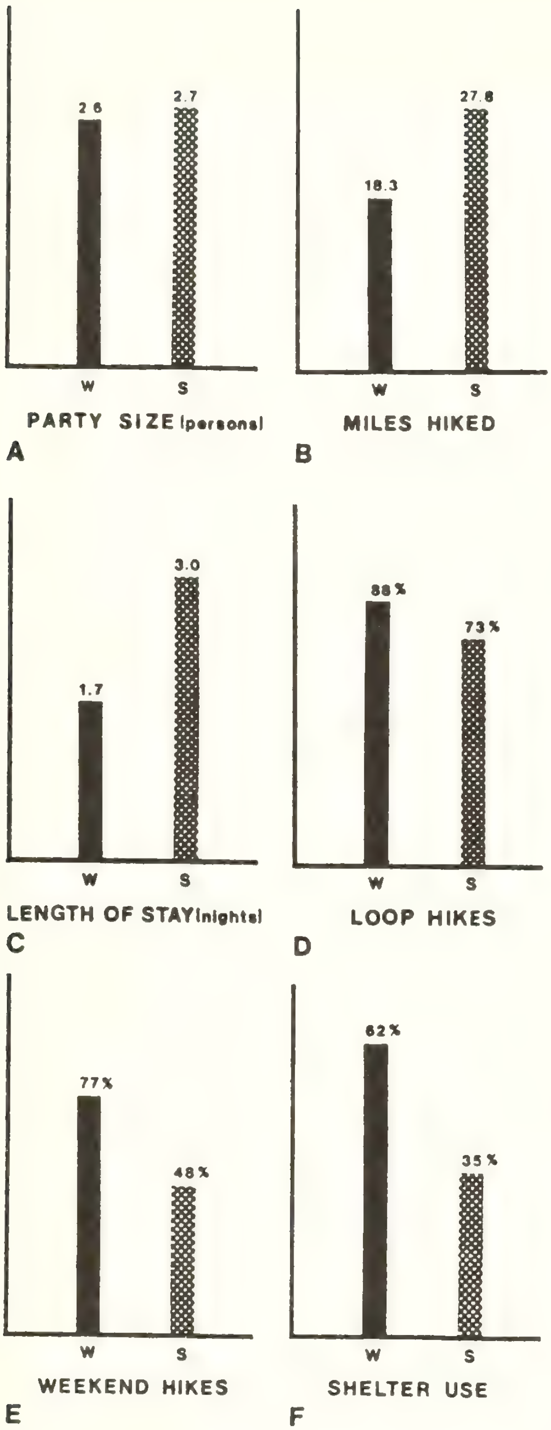

Figure 1.--Use patterns of winter and summer backcountry campers in Great Smoky Mountains National Park, 1979. Winter (W) has defined as use occurring in January and February, summer (S) was defined as use during August. All comparisons were significantly different at the 0.05 level, except party size.

using shelters was almost twice as high during the winter (62 percent versus 35 percent). Thus, the use patterns of winter and summer backcountry campers do not appear to be very similar.

Even though the user permit data indicate several differences between winter and summer backpackers, the data are limited to only use patterns. To examine other characteristics of winter users, a winter backcountry overnight use survey was conducted in 1981. Items included in the questionnaire were: (1) the background characteristics of winter overnight users, (2) the participation motives of winter users, and (3) the level of past experience of winter users, for both winter and all-season backpacking. Specific issues examined in this paper are:

1. Are winter wilderness users primarily younger males from the local area?
2. Are winter conditions and greater solitude the major motivations for engaging in winter wilderness recreation?
3. Is winter recreation a substitute for summer use?
4. Are winter users quite experienced at using wilderness?
5. Is experience level of winter users related to their motivations for winter backpacking?

METHODOLOGY

Study Area

Location of the study was Great Smoky Mountains National Park (GSMNP), in Tennessee and North Carolina. The Park is the most heavily visited National Park in the United States, receiving around 8 to 9 million visits per year. Backcountry overnight visits total about 80,000 camper nights per year. The backcountry camping resource consists of over 850 miles (1,368 km) of foot and horse trails, approximately 82 designated backcountry campsites, and 18 shelters. Thirteen of the 18 shelters are located on the Appalachian Trail.

The Great Smoky Mountains National Park, currently under Wilderness designation review, receives considerable off-season use. The GSMNP is now a three-season Park, with intense backcountry use extending from mid-March through late October (fig.2). Unlike many backcountry areas, camper nights usually peak during March and April, instead of July and August. Even during the four winter months of November through February, use averaged between 2,000 and 3,000 camper nights per month, 1976-82.

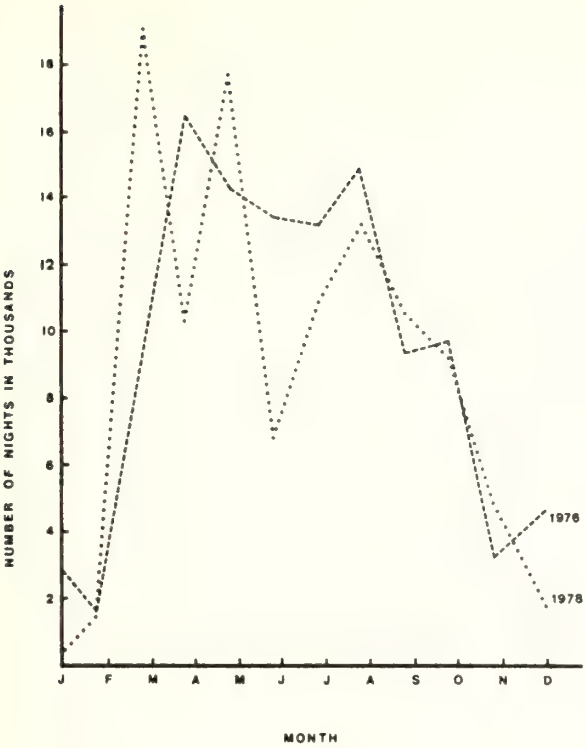

Figure 2.--Monthly pattern of backcountry overnight use in Great Smoky Mountains National Park, 1976 and 1978.

Study Area Winter Environment

The winter season for this study was defined as the months of January and February. Little snow falls in GSMNP at the lower elevations before late December, and the spring flora can begin blooming as early as late February. U.S. Weather Bureau statistics indicate that for Gatlinburg, TN--located at the Park's boundary at an elevation of 1,482 ft (452 m)--the average monthly temperatures for January and February are 39.3 °F (4.1 °C) and 41.9 °F (5.5 °C), respectively. Snowfall for the 2 months averages 2.1 inches (5.3 cm) and 2.3 inches (5.8 cm), respectively. Although snow rarely remains on the ground for more than a day or two at low elevations, the snow depth on the ridge tops of 6,200 ft (1,890 m) may exceed 6 ft (1.8 m) and remain for weeks. Long-term climatic records for the higher elevations of the Park are nonexistant; however, Shanks' work of 1949 and 1950 indicated that temperatures average 10-12 °F (-18.0 to -21.6 °C) lower at elevations above 5,050 ft. (1,539 m) (Shanks 1954).

Winter campers are routinely warned by park rangers of the unpredictability and possible dangers of winter weather. Sudden storms can result in extreme weather conditions and temperature changes. Hypothermia and frostbite are ever-present problems, and park personnel try to make winter campers knowledgeable about winter survival.

Questionnaire Design and Sampling Procedure

A two-page questionnaire was designed to collect data on the background characteristics, participation motives, and past experience levels of winter overnight users in the Park's backcountry. Participation levels in backcountry camping were obtained for all four seasons of the year, for both the Park and for areas outside the Park. The questionnaire was mailed to 300 randomly selected winter backcountry campers whose names and addresses were obtained from 1979 winter backcountry permits. A self-addressed, postage-paid, return envelope was included with the mailed survey. One postcard reminder was used to increase response, resulting in a 75 percent return rate.

Since only one name appeared on each backcountry permit, only that individual was sampled. Thus, interpretation of the data, particularly user characteristics, is limited to the group leader or person who completed the winter backcountry permit. Bias introduced by this procedure is discussed by Lucas and Oltman (1971). While we cannot account for the specific bias of our respondents, we would expect the group leaders to be more male, older, and more experienced than other party members. Concerning motivations, Lucas and Oltman reported no differences between party heads and other party members.

Questionnaire Content and Data Analysis

<u>Participation motives</u>.--Eighteen reasons for participating in winter backcountry use were rated for importance by respondents. A 5-point Likert format for rating importance was used, where 5=very important and 1=not important. The importance ratings were factor-analyzed to determine underlying themes or motivations for winter backpacking. Principal factoring with iteration and orthogonal varimax rotation was the factor analysis routine employed (Nie and others 1975). Factoring criteria included: factor loadings had to be ≤ 0.40 to be included in a factor, and only factors with eigen values ≥ 1.0 were extracted. To determine the internal consistency or reliability among items in a factor, Cronbach's alpha was employed.

<u>Past Experience Level</u>.--Past experience at backpacking was investigated several ways. General backpacking experience, in any backcountry area, was recorded by: (a) total number of years of backpacking experience, (b) average number of backpacking trips made per year, (c) the seasonal distribution of these trips, and (d) the average number of days spent backpacking per year. Backpacking experience specific to the GSMNP was also recorded by years of experience, trips per year, and seasonal distribution of trips. Number of winter and summer backpacking trips to GSMNP over the last 3 years was also determined.

Because we speculated that the winter backcountry user could be a specialized user with greater levels of past experience than the average peak season wilderness visitor, we analyzed the past experience variable several ways. First, four categories of past experience, based on area and season of backpacking participation, were formed. The four categories were:

PEO = Past Experience Overall (all seasons, any backcountry area)
PEW = Past Experience in Winter (winter season, any backcountry area)
PEOS = Past Experience Overall in Smokies (all seasons, only GSMNP)
PEWS = Past Experience in Winter in Smokies (winter season, only GSMNP)

Within each of these four categories of experience, users were classified according to four levels of experience, based on number of years backpacking or number of trips per year. The four levels were:

LOW = first year or participates in 1 or 2 trips per year
MODERATE = 2 to 4 years experience or 3 to 5 trips per year
HIGH = 5 to 10 years experience or 6 to 10 trips per year
VERY HIGH = 11 or more years or 11 or more trips per year

To test the relationship of past experience and motives for participating in winter wilderness backpacking, analysis of variance was used. The motivational themes resulting from the factor analysis comprised the dependent variable while the four levels of experience were the independent variables. For each motivation and category of experience, mean importance values by the four experience levels of users were tested for a significant difference ($p \leq 0.05$).

RESULTS AND DISCUSSION

Winter Camper Characteristics

Winter backcountry campers in GSMNP were 99 percent male and averaged 29.5 years of age. One third of the respondents fell into the 21 to 25-year-old category, with the following percentages in the other major age classes: 26 to 30 years (27 percent); 31 to 35 years (18 percent); and 36 to 60 years (17 percent). The high predominance of male respondents may be the result of having surveyed only group leaders or individuals who filled out backcountry permits. However, communication with GSMNP personnel confirms that males are more predominant among winter than summer campers.

The most frequently reported distance traveled (actual miles from residence) for a winter wilderness experience was 200 miles (322 km). Fifty-four percent of the respondents lived within 200 miles of the Park, while 74 percent lived within 300 miles (483 km). Thirty-one percent of the winter users were Tennessee residents, while another 40 percent came from the adjacent States of Georgia, North Carolina, Alabama, and South Carolina. Thus, winter use of wilderness is mainly regional, but is not restricted to local users.

Reasons for Winter Wilderness Use

The most important reasons for winter wilderness use involved enjoying winter scenery in the Smokies ($\bar{x}$=4.59), getting away from crowds (4.39), and experiencing the winter environment (4.36). Least important for winter participation were: less chance of encountering dangerous animals such as snakes and bears ($\bar{x}$=1.49), more free time in the winter (1.95), and not enough time for a long vacation (2.16).

When the individual reasons for participation were factor-analyzed, three factors or motivational themes were identified (table 1). The most important motivational theme, with a factor mean of 4.20, was experiencing the winter environment. Three of the four reasons grouping in this factor involved winter conditions: the scenery, environment, and weather. Following very closely in importance was the motivation of solitude, with a factor mean of 4.15. Escape from the crowds, fewer people during winter, and quietness were the reasons for winter backpacking in this factor. The least important theme, with a factor mean of 2.79, dealt with skill development and challenge. The mean of this factor was significantly different ($p \leq 0.05$) from that of the first two factors.

The data indicate that wilderness users are motivated to participate in winter backpacking because they want to experience the winter environment of wilderness and the quiet solitude of the winter use season. In a separate question, placed at the end of the questionnaire, we asked respondents specifically if they "tend to avoid packpacking in the GSMNP in the summer months due to heavy visitor use?" Approximately 78 percent of the winter users responded yes. Areas substituted for GSMNP during the summer peak use season were primarily: Joyce Kilmer-Slickrock Wilderness, National Forests adjacent to the Park (Cherokee, Pisgah, Nantahala), Linville Gorge Wilderness, and western wilderness areas. Thus, there is evidence to suggest that seasonal substitution may be occurring for winter users of GSMNP; they avoid using the area's backcountry during peak use seasons.

Table 1.--Factor analysis of reasons for winter backpacking in Great Smoky Mountains National Park

Factor	Factor loading	Factor mean	Factor alpha value[1]
Experiencing winter environment			
To enjoy the winter scenery in the Smokies	0.6306		
To experience the winter environment	0.4646	[2]4.20_a	0.51
To be close to nature	0.4385		
Prefer winter weather	0.4240		
Solitude			
To get away from the crowds	0.5897		
Fewer people than during the summer	0.8042	4.15_a	0.70
Quieter in the winter	0.5633		
Skill development/challenge			
To show that I could do it	0.4690		
To test new equipment	0.5243		
More risk involved	0.7775	2.79_b	0.80
More challenging in the winter	0.7069		
To test survival backpacking skills involved	0.8144		

[1]Cronbach's alpha was used as a measure of internal consistancy within factors.
[2]Factor means with the same subscript were not significantly different at the 0.05 level. Means based on the scale: 1=not important to 5=very important.

Past Experience of Winter Users

Past experience in backcountry/wilderness camping was recorded for all area use, and for use restricted to GSMNP. It was also recorded by seasonal use, that is, number of backpacking trips taken within each of the four seasons of a year (table 2).

Concerning overall backpacking experience, our respondents averaged 10 years, 6.7 trips per year, and 19.2 days per year of past experience. When restricted to backpacking in GSMNP, respondents averaged 7 years of experience and 3.7 trips per year.

On a seasonal basis, winter backcountry users made significantly more winter trips than summer, fall, or spring trips ($F=4.54$, $p\leq 0.001$). Users averaged about twice the number of winter trips as summer trips. Only 12 percent of the respondents made three or more summer backpacking trips per year, while 32 percent made three or more winter trips annually. Winter is clearly the backpacking season most popular with winter campers, while fall is slightly more popular than spring.

Concerning winter experiences only in GSMNP, respondents also used the Park backcountry twice as often in winter as in each of the other three seasons (table 2). During the 3-year period prior to our survey, winter campers indicated they had taken 4.8 winter

Table 2.--Backcountry camping experiences of winter wilderness users, Great Smoky Mountains National Park. Experience is recorded as past use for all backcountry areas, and specifically for Great Smoky Mountains National Park

Experience	All backcountry/ wilderness areas	Great Smoky Mts. National Park
Years of experience	10.3	7.0
Trips per year	6.7	3.7
Days per year	19.2	[1]N.A.
Seasonal distribution of trips per year[2]		
Summer	[3]1.3	0.6
Fall	1.7	0.8
Winter	2.3	1.7
Spring	1.5	0.7

[1]Average number of days backpacking per year was not recorded for Great Smoky Mountains National Park.
[2]Seasons were defined as: summer (June-August), fall (September-November), winter (December-February), spring (March-May).
[3]Seasonal mean values within columns were significantly different at $p\leq 0.001$.

backpacking trips compared to 2.0 summer trips in GSMNP. Thus, users of the backcountry of GSMNP during the winter tend to use both its wilderness environment, and wilderness environments in general, nearly twice as often during the winter as summer season. This preference for winter backpacking trips is in agreement with their motivations for winter backpacking--to experience the winter environment and its quiet solitude. The tendency toward more winter participation also supports the notion that winter users of GSMNP may be avoiding summer use due to peak-season use levels.

Levels of Experience of Winter Users

As indicated in the previous section, past experience can be acquired in several ways (years of experience, frequency of trips per year, number of days in the backcountry) and in different wilderness areas. For example, a wilderness user may have 12 years of experience, but only average one weekend trip per year, primarily to the same area. Another user may have only 4 years of experience, but average five trips per year, each trip being 3 to 5 days in length. Recently, various researchers have attempted to classify river recreationists according to "levels" of experience, based on various combinations of experience variables (Hammitt and McDonald 1983; Schreyer and Lime 1984; Schreyer and others 1984). Number of years of experience, trips per year, and number of rivers floated have been used to place river users into various levels or classes of experience.

Table 3 indicates the percentage of winter backpackers that placed in each of our experience levels. The majority of winter users were classified as HIGH or VERY HIGH in past experience. No one was classified as LOW in experience. Of particular interest was the similarity in experience of winter users for overall use (PEO) versus experience restricted to the winter season (PEW). For both categories of use, nearly 90 percent of the respondents were classified as HIGH or VERY HIGH in experience. A third of these individuals indicated that they have been backpacking for 11 or more years or take 11 or more trips per year. Winter backpackers are more experienced than the majority of summer wilderness users (Hendee and others 1978; Lucas 1980).

Relationship of Experience Level and Wilderness Motivations

Level of winter user experience was compared with motivations for participating in winter backpacking to see if more experienced users had higher levels of motivation. The comparison was done for each of the four categories of area/season experience (table 4).

Only the motivation of solitude differed significantly ($p \leq 0.05$) as experience level increased. For the experience categories of overall past experience and past experience in winter, the motivation for solitude increased significantly between users of MODERATE and HIGH experience. No significant difference was found as experience increased from the HIGH to the VERY HIGH level.

Upon first interpretation of these results, one might conclude that experience level has little to do with the reasons why one engages in winter wilderness use. Yet, it is important to know that all winter users consider the winter wilderness environment a very strong motivational force for winter camping. Secondly, the fact that desire to experience solitude did change in importance according to experience level, while experiencing the winter environment did not, has meaning. Both of the motivations received similar importance means, 4.20 versus 4.15 (table 1). Yet, solitude varied with experience level while environment did not. It may be that solitude is a more sensitive wilderness issue with experienced users than the experiencing of the winter environment. The winter environment is a unique and important aspect of winter wilderness,

Table 3.--Levels of past experience by category of past experience for winter backpackers in Great Smoky Mountains National Park (N=173)

Experience level	Experience categories[1]			
	PEO	PEW	PEOS	PEWS
	Percent			
Low	0.0	0.0	0.0	0.0
Moderate	9.3	11.6	26.6	53.2
High	49.1	55.5	46.8	38.7
Very high	41.6	32.9	26.6	8.1

[1]PEO = Past Experience Overall
PEW = Past Experience in Winter
PEOS = Past Experience Overall in Smokies
PEWS = Past Experience in Winter in Smokies

Table 4.--Relationship of experience level to motivations for participating in winter backcountry use, by four area/season categories of past visitor use

Participation motive and experience category[1]	Average experience level			ANOVA F-value	Significance
	Moderate	High	Very high		
Winter environment					
PEO	4.44	4.42	4.40	0.04	0.95
PEW	4.46	4.41	4.40	0.08	0.92
PEOS	4.40	4.41	4.42	0.02	0.98
PEWS	4.39	4.43	4.46	0.16	0.86
Solitude					
PEO	3.63	4.24	4.09	3.94	[2]0.02
PEW	3.70	4.22	4.11	3.25	[2]0.04
PEOS	3.96	4.27	4.02	2.53	0.08
PEWS	4.06	4.23	3.97	1.00	0.37
Skill development					
PEO	2.70	2.87	2.75	0.43	0.65
PEW	2.62	2.88	2.73	0.91	0.40
PEOS	2.73	2.90	2.70	0.91	0.40
PEWS	2.82	2.83	2.56	0.54	0.58

[1]PEO = Past Experience Overall
PEW = Past Experience in Winter
PEOS = Past Experience Overall in Smokies
PEWS = Past Experience in Winter in Smokies
[2]Statistically significant at $p \leq 0.05$

but the high degree of quiet solitude associated with it is what the more experienced wilderness user really values.

SUMMARY AND IMPLICATIONS

The study of outdoor recreationists from the perspective of experience level and cognitive development is just beginning to be explored. We feel that knowledge of past experience is important for understanding the needs and preferences of a select subgroup of wilderness users such as winter backpackers. Because this group of wilderness users is highly experienced, we can hypothesize that they will vary from other users in their behavior and preferences toward wilderness management. The purpose of our study was to establish the use patterns and experience levels of winter backpackers and to relate the use history of winter campers to motives for winter participation in wilderness. However, there are many other management variables besides participation motives for which past experience and winter participation in wilderness may have meaning.

Our findings suggest that the use patterns and experience levels of winter wilderness users may be different enough from summer, peak season users that management of these two wilderness groups needs further research, and possibly, different approaches. For example, are use permits necessary for the experienced winter users? If they have used an area a great deal in the past, and are now using it in winter to avoid crowds, they need little information on dispersal. At the same time, because solitude is so very important to experienced users, maps of use distribution will be very useful to them in trip planning. Carrying capacities, likewise, will have to be lower for winter users than for summer users, in order to provide solitude. Lack of vegetation during winter in hardwood forests greatly increases the visual and noise parameters affecting solitude.

Winter users of wilderness are more experienced than the average user (Lucas 1980), and past experience is known to lead to user specialization of recreation resources (Bryan 1979) and preference for their management (Hammitt and McDonald 1983; Schreyer and Lime 1984; Schreyer and others 1984). Of particular interest in our results was the degree of area substitution on a seasonal basis by winter users. More research is needed in other wilderness areas to determine the prevalence and importance of area substitution and user displacement among winter recreationists. Winter backpackers provide an important opportunity to examine individuals that have been displaced, and the

use/management causes for displacement. They also present the opportunity to study how experienced users specialize in wilderness equipment and resources during winter camping. For the manager, promoting off-season wilderness use is a means of providing a quality solitude substitute for the peak season displaced user.

Concerning the basic question of whether resource managers can use the significant amount of existing peak-season backcountry/wilderness data to understand and manage off-season use, the answer is not definite. Unlike earlier studies that demonstrated little basis for a geographical difference between the user characteristics, experience levels, and patterns of use of western versus eastern wilderness users (Boteler 1981; Lime 1976; Roggenbuck 1980), the situation may not be the same for a seasonal difference between peak and off-season use. Our data indicate that the winter campers of GSMNP are experienced backpackers who may be seeking an experience different from that found, or not available, during peak-season camping. Avoidance of GSMNP during the heavy use season, and involvement in more winter than summer backpacking trips, can have important managerial implications for wilderness areas, particularly management for solitude. Until more research is conducted on winter use, we feel that resource managers and researchers need to be cautious about extrapolating peak season backcountry findings to off-season backcountry use. Data on summer users may be only partially applicable to winter users. It is important to keep in mind that winter backcountry users are a subset of backcountry users that have self-selected to use wilderness during this time of the year, probably because of their experience level and expectations for a wilderness experience. Both researchers and managers may have to deal with this group of users in ways different from those of summer wilderness users.

Finally, because of the lack of previous research on winter users of wilderness, and the degree of differences found from typical peak season use, our findings should be used cautiously for determining winter wilderness management practices. Our results will need to be replicated, and expanded, in other wilderness areas before conclusive policies concerning winter backcountry use can be formed.

REFERENCES

Boteler, F. E. Eastern and western wildland users: a comparison of their characteristics with implications for management decision making. In: Social science research in National Parks and wildland areas conference: Proceedings; 1980 March 21-22; Gatlinburg, TN. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Region; 1981: 99-105.

Bratton, S. P.; Hickler, M. G.; Graves, J. H. Visitor impact on backcountry campsites in the Great Smoky Mountains. Environ. Manage. 2(5):431-442; 1978.

Bryan, H. Conflict in the great outdoors. Soc. Stud. No. 4. University, AL: University of Alabama, Bureau of Public Administration; 1979. 99 p.

Cannon, L. K.; Adler, S.; Leonard, R. E. Factors affecting dispersion of backcountry campsites. Res. Note NE-276. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1979. 6 p.

Echelberger, H. E.; Moeller, G. H. Use and users of the Cranberry Backcountry in West Virginia: insights for eastern backcountry management. Res. Pap. NE-363. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1977. 8 p.

Hammitt, W. E.; Hughes, J. L. Characteristics of winter backcountry use in Great Smoky Mountains National Park. Environ. Manage. 8(2):161-166, 1984.

Hammitt, W. E.; Loy, J. Behavior of winter backcountry users in Great Smoky Mountains National Park. In: Social science research in National Parks and wildland areas conference: Proceedings; 1980 March 21-22; Gatlinburg, TN. Atlanta, GA: U.S. Department of the Interior, National Park Service, Southeast Region; 1981:11-21.

Hammitt, W. E.; McDonald, C. D. Past on-site experience and its relationship to managing river recreation resources. For. Sci. 29(2):262-266; 1983.

Hendee, J. D. A scientist's view on some current wilderness management issues. West. Wildlands. 1(2):36; 1974.

Hendee, J. C.; Catton, W. R., Jr. Wilderness users--what do they think? Amer. For. 74(9):29-31, 60-61; 1968.

Hendee, J. C.; Catton, W. R., Jr.; Marlow, L. D.; Brockman, C. F. Wilderness users in the Pacific Northwest--their characteristics, values, and management preferences. Res. Pap. PNW-61. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 1968. 92 p.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Misc. Publ. No. 1365. Washington, D C: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Hughes, J. L. Winter backcountry campers in The Great Smoky Mountains National Park: their behavior, use patterns, and characteristics. Knoxville, TN: University of Tennessee; 1985. 116 p. M.S. Thesis.

Leonard, R. E.; Echelberger, H. E.; Schnitzer, M. Use characteristics of the Great Gulf Wilderness. Res. Pap. NE-428. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1978. 9 p.

Lime, D. W. Wilderness use and users: a summary of research. In: Society of American Foresters 54th annual winter meeting: Proceedings; 1976 February 3-6; Dover, DE. Bethesda, MD: Society of American Foresters; 1976. 19 p.

Lime, D. W.; Buchman, R. G. Putting wilderness permit information to work. J. For. 72(10): 622-626; 1974.

Lucas, R. C. Forest Service wilderness research in the Rockies: what we've learned so far. West. Wildlands. 1(2):5-12; 1974.

Lucas, R. C. Use patterns and visitor characteristics, attitudes and preferences in nine wilderness and other roadless areas. Res. Pap. INT-253. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 89 p.

Lucas, R. C.; Oltman, J. L. Survey sampling wilderness users. J. Leisure Res. 3(1):28-42; 1971.

Merriam, L. C., Jr.; Ammons, R. B. Wilderness users and management in three Montana areas. J. For. 66(5):390-395; 1968.

Murray, J. C. Appalachian Trail users in the southern National Forests: their characteristics, attitudes, and management preferences Res. Pap. SE-116. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1974. 19 p.

Nie, N. H.; Hull, C. H.; Jenkins, J. G.; Steinbrenner, K.; Bent, D. H. (Eds.). Statistical package for the social sciences. New York: McGraw-Hill Book Company. 1975. 675 p.

Roggenbuck, J. W. Wilderness user preferences: eastern and western areas. In: Wilderness mgmt. symposium: Proceedings; 1980 November 13-15; Knoxville, TN: University of Tennessee; 1980:103-146.

Roggenbuck, J. W.; Timm, W. N.; Watson, A. E. Visitor perception of the recreation carrying capacity of three wilderness areas in North Carolina. Blacksburg, VA: Virginia Polytechnical Institute and State University, Department of Forestry and Wildlife Resources; 1979. 303 p.

Schreyer, R.; Lime, D. W. A novice isn't necessarily a novice - the influence of experience use history on subjective perceptions of recreation participation. Leisure Sci. 6(2):131-149; 1984.

Schreyer, R.; Lime, D. W.; Williams, D. R. Characterizing the influence of past experience on recreation behavior. J. Leisure Res. 16(1):34-50; 1984.

Shanks, R. E. Climates of the Great Smoky Mountains. Ecology. 35(3):354-361; 1954.

Stankey, G. H. Visitor perception of wilderness recreation carrying capacity. Res. Pap. INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973; 61 p.

Stankey, G. H.; Lucas, R. C.; Lime, D. W. Patterns of wilderness use as related to congestion and solitude. Seattle, WA: Association of American Geographers annual meeting; 1974. 17 p. Unpublished paper.

ACTIVITIES, ATTITUDES, AND MANAGEMENT PREFERENCES OF RECREATIONISTS ON THE ARCTIC NATIONAL WILDLIFE RANGE, ALASKA

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ABSTRACT: A descriptive study of recreationist activities, attitudes, and management preferences was conducted on the Arctic National Wildlife Range (ANWR) in northeastern Alaska. The majority of the sampled ANWR recreationists in 1977 were male, between 25 and 44 years old, and college educated. Recreationists were generally very satisfied with their trip. Satisfaction for hunters was associated with hunting success. Developments were generally opposed; general information was desired; and limiting plane landings was the most preferred of three proposed rationing systems. The limiting social factor for hunters was sightings of groups, and the limiting social factor for recreationists not hunting was light aircraft sightings.

INTRODUCTION

Purpose and Objectives of Study

During the mid 1970's, with the discovery of oil at Prudhoe Bay, and consideration of an Alaska National Interest Lands Conservation Act (ANILCA) in Congress, arctic Alaska received considerable national and international attention. In response to increased interest and recreational use in the arctic, the U.S. Department of the Interior, Fish and Wildlife Service, in cooperation with the University of Idaho, sponsored a descriptive recreational use study in the Arctic National Wildlife Range (ANWR), Alaska (Warren 1980).

Information obtained from the study was to aid managers in accomplishing the ANWR objectives of preserving the area's unique wildlife, wilderness, and recreational values (Public Land Order 2214). Collected information was to provide descriptive information for a recreational use management plan, provide a framework for nonregulatory approaches to managing recreational use to maintain impacts within the limits of acceptable change (Frissel and Stankey 1972), and identify rationing tools that recreationists believed would be the most desirable in the ANWR, if necessary.

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The specific study objectives were to:

1. Estimate the number of recreationists per year and length of stay.
2. Determine if hunters and recreationists not hunting (nonhunters) were significantly different with regard to activities, attitudes, and management preferences.
3. Determine socioeconomic characteristics of recreationists.
4. Identify group size and type of recreational activities being engaged in by recreationists.
5. Determine attitudes toward wildlife, wilderness, light aircraft use, and recreational use management alternatives.
6. Determine degree of trip satisfaction of recreationists.
7. Estimate social carrying capacity for recreational use.

When ANILCA became law, the Wildlife Range was enlarged to 18 million acres and renamed the Arctic National Wildlife Refuge. The information presented here was collected during the formulation of the ANILCA legislation and provides specific descriptive data for the Arctic National Wildlife Refuge Comprehensive Plan, and may also be applicable to management of other Alaska areas.

Study Area

The ANWR is located in northeastern Alaska, and at the time of this study comprised 8.9 million acres. All but 1.4 million acres of the coastal plain of the study area are now classified wilderness.

The study area contains four major physiographic units: the Arctic Coastal Plain, Arctic Foothills, Eastern Brooks Range, and the Porcupine Plateau (Warfhatig 1965). Wet tundra is found along the coast; moist tundra dominates the foothills; alpine or dry tundra is associated with mountainous areas. Outcrop and talus communities predominate on slopes in the mountains. High brush is associated with watercourses; low brush and muskeg occur along rivers in the southern portion of the area; and upland spruce-hardwood forests are found in southern river valleys (Spetzmen 1959). Large mammals inhabiting the ANWR include barren ground caribou, Dall sheep, muskox, wolves, moose, and grizzly bear.

METHODOLOGY

Recreational Use Estimates and Sample Design

Recreationists' access patterns were not known in sufficient detail to design a stratified random sample for obtaining a questionnaire mailing list. However, all major access methods and points were known; therefore, it was possible to attempt to census the recreationist population. Names and addresses were obtained from several sources including commercial guides, air taxi services, and the Alaska Department of Fish and Game. In addition, registration stations were established at airfields at Barter Island, Fairbanks, and Fort Yukon following procedures of Lucas and Oltman (1971).

To estimate the success of obtaining a recreationist census, confirmed complete lists of commercial guide clients were obtained. By comparing the names of the recreationists using guide services with the list of names of recreationists obtained from other sources, the percentage of the recreationists not included in the census attempt could be estimated. From these estimates, census coefficients were developed for both hunters and nonhunters. The census coefficients were used to estimate total use by calibrating the lists of hunters and nonhunters by the appropriate coefficient.

The final list of recreationists was neither a random sample nor a census. Recreationists using guide services had the same opportunity as other recreationists to have their names obtained from other mailing list sources. Using this knowledge, determination was made as to whether the complete mailing list included a representative sample of recreationists to the ANWR. This was accomplished by comparing responses from those whose names were obtained from only a commercial guide with the responses of the other recreationists.

The Native Indians and Eskimos visiting the ANWR were not represented in this survey. A questionnaire was not an appropriate tool for gathering information from these groups of visitors.

Questionnaire

A questionnaire was designed to gain information about the recreationists' socioeconomic characteristics, activities in the ANWR, satisfaction, and attitudes toward recreational use and management. The questionnaire was mailed to all persons whose names and addresses were obtained. Procedures similar to those described by Dillman and Christenson (1974) were employed to achieve a high return rate on the questionnaire. The procedures included followup mailings and providing postage-paid envelopes.

Statistical Analysis

Chi-square statistic was used to determine whether a systematic relationship existed between hunters, nonhunters, wilderness attitudes, and other selected questions. For Chi-square analysis, a significant difference was defined as one that would have occurred by chance no more than 5 percent of the time--0.05 level of significance. Gamma ranges from -1 to 1; its numerical value, disregarding sign, gives the percentage of guessing errors eliminated by using knowledge of a second variable to predict order. Thus, the numerical value of gamma represents the degree of association, while the sign represents negative or positive association.

Carrying Capacity

Management decisions on carrying capacity should be made by utilizing recreationists' input in some selective and systematic manner. An approach suggested by Frissell and Stankey (1972) is to relate recreationists' objectives to management objectives. This study related recreationists' objectives to management objectives by using a purism scale developed by Stankey (1973). This purism scale measured the degree to which recreationists agreed with the definition of wilderness as presented in the Wilderness Act. Ten items in the scale were concerned with three characteristics of wilderness as defined by the Wilderness Act: a natural ecosystem, minimal human development, and primitiveness of recreational activities. The remaining four items related to other attributes of a wilderness: solitude, little evidence of other recreationists, remoteness, and size of the area. Recreationists were asked to consider each item in the context of wilderness and rate it on a scale ranging from very undesirable to very desirable. Recreationists were grouped by their scores as defined by Stankey (1973), with the exception that Stankey's strong purists category was subdivided into strong purists and very strong purists.

Lime and Stankey (1971) defined carrying capacity as the character of use that can be supported over a specified time by an area developed at a certain level, without causing excessive damage to either the physical environment or the experience for the recreationist. Frissel and Stankey (1972) defined social carrying capacity as a limit of acceptable change. Other studies have measured social carrying capacity in terms of tolerance to intergroup encounters (Stankey 1973; Badger 1975; Nielson and Shelby 1977). Because of the dependence on the use of aircraft in this study area, encounters with both groups and aircraft were evaluated in terms of acceptable levels for both hunters and nonhunters. Social carrying capacity was estimated for hunters and nonhunters by requesting that the recreationists indicate the number of groups, light aircraft, and light aircraft landings that they could see and still have a satisfactory experience. Proximity to the limits of acceptable change was estimated by comparing the median average of actual encounters with the median average of the number of encounters that recreationists said they could have seen before satisfaction was decreased. Observation counts by recreationists were compared with overall visitation records to verify a strong association. Two categories were defined for

overall visitation records: high-use weeks and areas, and low- through medium-use weeks and areas. The high-use category consisted of recreationists who visited the five most heavily used zones during the seven highest use weeks.

RESULTS

Census

For nonhunting recreationists, an estimated 93 percent of names and addresses were gathered. Names and addresses were obtained for 60 percent of the estimated hunter population. For hunters, the validity of the results is highly dependent on noncontacted recreationists not being significantly different from contacted recreationists. Chi-square tests identified no statistically significant differences for noncontacted hunting guide clients and contacted hunters, with regard to attitudes toward wilderness and selected management preferences.

Questionnaire Response

The questionnaire was mailed to 594 individuals. Nonrespondents totaled 14 percent of the sampled population. Information known about this group included registration site(s), gender, and place of residence. Since the list of names and addresses inadvertently included nonvisitors (mostly Defense Early Warning station employees) and nonrecreationists, the actual return rate for recreationists probably exceeded 90 percent. Chi-square analysis to test for differences between respondents and nonrespondents did not identify any source of names and addresses that resulted in significantly different questionnaire return rates. In addition, analysis of residence (Alaska or non-Alaska) and gender did not identify any statistically significant differences in return rates.

Total Use

In 1977, an estimated 434 recreationists visited the ANWR; 248 were sport hunters (70 percent confidence interval of 192 to 305) and 186 were nonhunters (70 percent confidence interval of 175 to 195). Hunter-use-days totaled 5,260, while there were 4,990 nonhunter-use-days, for a total of 10,240 recreational-use-days (one recreational-use-day equals 12 hours aggregate stay). Recreational-use-days per acre in 1977 were 0.0012.

Comparison of Hunters and Nonhunters

For most sport hunters, the most important activity was hunting. Nonhunters were diverse with regard to "most important" activity identified and listed backpacking/hiking, viewing scenery, observing wildlife, and wilderness experience. When the activity listed by nonhunters as "most important" was compared with wilderness attitudes, no significant difference was detected.

Hunters and nonhunters were significantly different with respect to most of their attitudes and management preferences, including their attitudes toward wilderness, increased use, and rules and regulations (table 1). Median wilderness purism values were 60 for hunters and

Table 1.--Differences between hunters and nonhunters

User group	Purism scores: Nonpurist - moderate purist	Strong purist	Very strong purist	Valid cases
	Percent			
Hunter	47	32	20	137
Nonhunter	13	26	61	159

Chi-square = 60.66 Significance = 0.001 Gamma = 0.67 Total cases = 300

User group	Allow increased use without restriction: Strongly oppose	Oppose	Neutral	Favor	Strongly favor	Valid cases
	Percent					
Hunter	24	31	19	14	12	139
Nonhunter	50	37	7	5	2	153

Chi-square = 41.52 Significance = 0.001 Gamma = -0.53 Total cases = 300

User group	Rules and regulations to maintain the quality: Very undesirable	Undesirable	Neutral	Desirable	Very desirable	Valid cases
	Percent					
Hunter	9	7	10	46	28	136
Nonhunter	1	4	9	42	44	154

Chi-square = 15.18 Significance = 0.004 Gamma = 0.32 Total cases = 300

66 for nonhunters. A very high gamma value of 0.67 indicates that purism scores tended to be higher for nonhunters. Allowing use to increase without restriction was opposed by hunters, while it was strongly opposed by nonhunters. Rules and regulations to maintain quality were desirable for hunters and very desirable for nonhunters.

No significant differences were identified between Alaskan and non-Alaskan hunters, or between Alaskan and non-Alaskan nonhunters with respect to wilderness attitudes.

Socioeconomic Characteristics

Seventy-eight percent of the sampled hunters and 63 percent of the sampled nonhunters were between 25 and 45 years old. Individuals younger than 25 comprised 7 and 22 percent of the hunters and nonhunters, respectively. Hunters were 96 percent male, while nonhunters were 71 percent male.

Most recreationists were from Alaska and Pacific Coastal States (California, Oregon, and Washington). Sixty-seven percent of the hunters lived in Alaska, while 10 percent were from the Pacific Coastal States. Thirty percent of the nonhunters were from Alaska, and 30 percent lived in the Pacific Coastal States.

Median average annual incomes for Alaskan and non-Alaskan hunters were $33,900 and greater than $40,000, respectively. Median average annual incomes for Alaskan and non-Alaskan nonhunters were $25,400 and $17,700, respectively.

Hunters and nonhunters in professional-technical and management-administrative occupations accounted for 48 and 58 percent of the ANWR recreationists, respectively. Seventy percent of the hunters and 92 percent of the nonhunters had some college education. Twenty-nine percent of the hunters and 63 percent of the nonhunters had completed over 16 years of formal education.

Recreational Activities, Group Size, and Length of Stay

Although prior experience in backcountry and wilderness was quite diverse among the recreationists, ranging from less than four trips to over 100, there was no significant systematic relationship with the "most important" activity identified. Each major activity group had approximately the same breadth of backcountry and wilderness experience.

Forty-two and 4 percent of the hunters and nonhunters, respectively, used a private or rented plane with a group member as pilot of the plane. Almost all the other recreationists hired an air taxi service. The most common method of travel included combination of an aircraft flight into the Wildlife Range with hiking. One group hiked the entire length of the ANWR. One guide in 1977 flew to all camps, thus reducing hiking by recreationists using his services.

Besides sport hunting, over 50 percent of the hunters indicated participating in backpacking/hiking, camping, observing wildlife, photography, viewing scenery, and flying. Over 50 percent of the nonhunters indicated participating in observing wildlife, backpacking/hiking, photography, observing plants, viewing scenery, and camping. Although there are a few activities that are the recreationists' focal point of a trip in the ANWR, many activities added to their total experience.

Ninety-six percent of the hunters visited in groups of less than seven people. Fifty-four percent of the nonhunter groups were less than seven people. For hunters and nonhunters, group size ranged from one to 15 people.

Length of stay ranged from 2 to 61 days. The mean average length of visit for hunters was 11 days, and 13 days for nonhunting recreationists. The median length of visit for hunters and nonhunters were 8 and 11 days, respectively.

Recreationist Attitudes

The presence of wildlife in the ANWR was important or very important to almost all recreationists. Thirty-four and 61 percent of the hunters indicated that wildlife was important and very important, respectively. Sixty-one and 30 percent of the nonhunters indicated that wildlife was important and very important, respectively. Approximately 75 and 42 percent of the hunters and nonhunters, respectively, saw as much or more wildlife than they expected.

Attitudes toward wilderness, as shown earlier, were not significantly different between Alaskan and non-Alaskan residents. Prior experience in backcountry and wilderness areas was not shown to be significantly different between wilderness purism groups.

Some use of light aircraft was generally accepted by hunters and nonhunters: only 4 and 8 percent of these groups, respectively, indicated that they wished to see no aircraft. However, 41 percent of the hunters and 60 percent of the nonhunters indicated that three light aircraft would be the maximum number to see or hear in 1 week and still have a satisfactory experience.

Developments were generally opposed by both hunters and nonhunters. Specifically they believed bridges, manmade trails, improved landing strips, and cabins at the largest lakes in the study area were undesirable (table 2).

Nonhunters' responses ranged from neutral to strongly favoring low-impact use regulations, including moving their camp, using gas stoves, prohibiting pack animals, and removing their trash. Hunters were strongly opposed to moving their camp and using gas stoves only; they were neutral toward prohibiting pack animals, and they strongly favored removing their own trash.

Table 2.--Attitudes of hunters (H) and nonhunters (NH) toward recreational-use developments

Development		1 VUD[1]	2 UD	3 N	4 D	5 VD	Median response	Valid cases
		Percent						
Bridges across rivers	H	81	12	4	2	2	1.1	139
and streams	NH	70	24	3	3	0	1.2	152
Manmade trails	H	73	17	7	1	2	1.2	138
	NH	72	20	6	1	1	1.2	159
Improved light aircraft	H	61	21	7	4	7	1.3	138
landing strips	NH	52	26	16	5	2	1.5	157
Cabin at lake Peters/	H	49	11	22	13	6	1.6	136
Schrader for public use	NH	36	20	27	13	4	2.2	158

[1] VUD=Very Undesirable UD=Undesirable N=Neutral D=Desirable VD=Very Desirable

Recreationists were asked to respond to the desirability of three rationing systems. These systems involved timing of trips, issuing permits, and limiting plane landings. The most favored rationing system was to limit plane landings (table 3).

Availability of information was neutral to very desirable to most recreationists, including general information on what to see, what to expect, and low-impact camping techniques (table 4). Detailed information was less desirable than general information.

Trip Satisfaction

Seventy-nine percent of the hunters and 84 percent of the nonhunters indicated that they were very satisfied with their trip in the ANWR. Trip satisfaction for hunters was related to hunting success. For hunters, satisfaction may be affected by intergroup encounters (Chi-square significance of 0.07), while for nonhunters satisfaction may be affected by the number of light aircraft seen (Chi-square significance of 0.11). High gamma values indicate a strong association in the expected direction (table 5).

Table 3.--Attitudes of hunters (H) and nonhunters (NH) toward regulations

Regulation		1 SO[1]	2 O	3 N	4 F	5 SF	Median response	Valid cases
		Percent						
Require visitors to move camp every other night to protect vegetation	H	43	35	12	7	3	1.3	139
	NH	8	29	17	29	17	3.2	157
Require visitors to	N	43	29	17	5	7	1.7	139
use gas stoves only	NH	9	18	15	22	36	3.9	159
Prohibit pack animals	H	20	15	30	13	23	3.0	138
	NH	3	9	20	18	50	4.5	159
Require visitors to	H	3	5	2	21	69	4.8	136
carry out their trash	NH	0	1	1	8	90	4.9	159
Regulate the timing	H	37	34	18	7	5	1.9	137
of trips	NH	15	26	23	26	11	2.9	148
Require visitors to obtain a permit for all areas, limiting the number of permits in heavily used	H	33	24	17	14	12	2.2	137
areas only	NH	8	10	10	42	30	4.0	156
Limit number of planes that can land in any	H	25	18	22	19	17	2.8	139
one zone per week	NH	5	11	21	27	36	4.0	155

[1] SO=Strongly Oppose O=Oppose N=Neutral F=Favor SF=Strongly Favor

Table 4.--Desirability of providing recreationist information; H indicates hunters, NH nonhunters

Information		1 VUD[1]	2 UD	3 N	4 D	5 VD	Median response	Valid cases
		Percent						
General information available about where to go and what to see	H	24	9	25	28	15	3.2	139
	NH	11	9	30	33	17	3.5	159
Information about what to expect	H	20	4	25	29	23	3.6	138
	NH	3	2	23	44	28	4.0	160
Information available about low impact camping techniques	H	14	4	23	27	32	3.9	139
	NH	2	1	9	24	64	4.7	160

[1] VUD=Very Undesirable UD=Undesirable N=Neutral D=Desirable VD=Very Desirable

Table 5.--Relationship between trip satisfaction and hunting success, and the number of groups and aircraft seen

Hunters	Hunting Success No	Hunting Success Yes	Valid cases
	Percent		
Less than very satisfied	48	52	27
Very satisfied	24	76	107

Chi-square = 5.94 Significance = 0.02 Gamma = 0.49 Total cases = 139

	Groups Seen 0	1 to 3	4+	Valid cases
	Percent			
Less than very satisfied	19	56	25	16
Very satisfied	47	44	10	73

Chi-square = 5.40 Significance = 0.07 Gamma = -0.52 Total cases = 139

Nonhunters	Aircraft Seen 0	1 to 3	4+	Valid cases
	Percent			
Less than very satisfied	10	52	38	21
Very satisfied	26	54	20	113

Chi-square = 4.41 Significance = 0.11 Gamma = -0.42 Total cases = 161

Social Carrying Capacity

Sampled hunters indicated that they observed a median average of 1.5 visitor groups, 2.7 light aircraft, and 0.7 aircraft landings per week. Sampled nonhunters indicated observing a median average of 0.9 visitor groups, 2.5 light aircraft, and 0.7 aircraft landings per week. Observation counts made by the recreationists were highly associated with overall visitation patterns (table 6).

Hunters indicated being able to see a median average of 2.8 groups, 5.8 light aircraft, and 2.3 light aircraft landings per week and still have a satisfactory experience. Thus, hunters indicated being able to see 87 percent more groups, 115 percent more light aircraft, and 156 percent more aircraft landings than observed. These figures suggest that the limiting measured social factor for hunters is group sightings. As shown earlier, trip satisfaction results support this finding. Twenty-five percent of the hunters saw more than three groups.

Nonhunters indicated being able to see a median average of 2.3 groups, 3.4 light aircraft, and 1.3 light aircraft landings per week and still have a satisfactory experience. This is 156 percent more groups, 36 percent more light aircraft, and 86 percent more aircraft landings than what nonhunters observed. This suggests that aircraft sightings is the limiting measured social factor for nonhunters. As shown earlier, trip satisfaction results support this finding. Twenty-five percent of the nonhunters saw more than three light aircraft.

Table 6.--Relationships between groups and light aircraft seen compared to visitation patterns

All groups	Groups seen 0	1 to 3	4+	Valid cases
	- - - - - Percent - - - - -			
High use week and area	32	49	19	37
Low-medium use week and area	55	39	6	154

Chi-square = 9.82 Significance = 0.01 Gamma = -0.61 Total cases = 300

	Aircraft seen 0	1 to 3	4 to 8	9+	Valid cases
	- - - - - - Percent - - - - - -				
High use week and area	14	46	19	22	37
Low-medium use week and area	20	58	17	5	154

Chi-square = 11.13 Significance = 0.01 Gamma = -0.34 Total cases = 300

Very strong purist recreationists indicated being able to see a median average of 2.1 groups, 3.0 planes, and 1.0 plane landing per week. As with nonhunters, these figures suggest that aircraft sightings is the limiting measured social factor.

For strong and very strong purists, no significant difference was detected between high-use and low-use time-and-area visits and the number of groups and planes indicated as being able to see and still have a satisfactory experience. However, for nonpurist through moderate purist groups, the more groups and planes seen, the more these groups indicated that they could see (table 7). This suggests that stronger purist groups have more crystallized beliefs regarding acceptable encounter levels.

Maximum group sizes recommended by hunters and nonhunters were nine and 11 (median values), respectively. Very strong purists recommended a median maximum group size of nine.

SUMMARY AND DISCUSSION

The surveyed hunters and recreationists that were not hunting were distinct groups. Their socioeconomic characteristics, activities, and attitudes toward management of the ANWR were generally different. Because of the differences between these groups, management should be targeted at each group individually. This should influence the design of recreationist information, educational materials, and regulations to manage use.

Lucas (1980) studied use patterns and recreationist characteristics, attitudes and preferences in eight wilderness and other roadless areas in the northern Rocky Mountains and one wilderness in California. His study included findings from the Desolation, Mission Mountains, Cabinet Mountains, Selway-Bitterroot, Bob Marshall, Scapegoat, and Great Bear Wildernesses, the Spanish Peaks Primitive Area, and the Jewel Basin Hiking Area.

Recreational-use-days per acre in the Great Bear Wilderness in 1976 was 58 times higher than 1977 levels in the ANWR, and the Great Bear Wilderness was the most lightly used wilderness in the Rocky Mountains and Desolation Wilderness study. However, social impacts of use levels in the arctic are not directly comparable to non-arctic areas, due to the openness of the arctic terrain and dependence on aircraft for transportation.

Socioeconomic characteristics of ANWR recreationists were similar to users of the Rocky Mountain areas and Desolation Wilderness with two notable exceptions. Education and income levels were above the national average for Rocky Mountain and Desolation Wilderness recreationists, but they were even higher for ANWR recreationists: 29 percent of the hunters and 63 percent of the nonhunters had some postgraduate education. Average incomes were very high, which was expected due to the costs associated with traveling to the ANWR and the relatively high Alaska salaries.

The average length of stay for recreationists was 11 days for hunters and 13 days for nonhunters. The longest average length of stay identified in the Rocky Mountain and Desolation Wilderness study was 5.7 days. Travel time and expense to reach the ANWR probably account for the much longer length of stay. Party sizes for groups visiting the ANWR were very similar to the averages found in the Rocky Mountain and Desolation Wilderness study.

Recreationists to the ANWR, the Rocky Mountains, and Desolation Wilderness participated in several of the same activities, including hiking, photography, nature study, and hunting. Participation in hunting involved an estimated 57 percent of the ANWR recreationists, and was identified by 2 to 43 percent of the Rocky Mountain and Desolation Wilderness study recreationists.

Table 7.--Comparison of the number of groups and planes visitors said they could see and still have a satisfactory experience

Nonpurist through moderate purists	Groups could see: 0 to 3	4 to 8	9+	Valid cases
	- - - - - - Percent	- - - - - -		
High use week and area	31	50	19	16
Low-medium use week and area	68	20	13	40

Chi-square = 6.54 Significance = 0.04 Gamma = -0.51 Total cases = 87

Strong purists	Groups could see: 0	1 to 3	4+	Valid cases
	- - - - - - - Percent	- - - - - -		
High use week and area	13	67	20	15
Low-medium use week and area	10	78	12	49

Chi-square = 0.78 Significance = 0.68 Total cases = 87

Very strong purists	Groups could see: 0	1 to 3	Valid cases
	- - Percent - -		
High use week and area	17	83	12
Low-medium use week and area	27	72	83

Chi-square = 0.66 Significance = 0.42 Total cases = 126

Nonpurist through moderate purists	Aircraft could see: 0 to 3	4 to 8	9 to 15	16+	Valid cases
	- - - - - - - - Percent	- - - - - - -			
High use week and area	13	19	25	44	16
Low-medium use week and area	43	30	10	18	40

Chi-square = 8.52 Significance = 0.04 Gamma = -0.58 Total cases = 87

Strong purists	Aircraft could see: 0	1 to 3	4 to 8	9 to 15	16+	Valid cases
	- - - - - - - - Percent	- - - - - - - -				
High use week and area	13	38	13	13	25	16
Low-medium use week and area	8	43	24	18	6	49

Chi-square = 5.37 Significance = 0.26 Total cases = 87

Very strong purists	Aircraft could see: 0 to 3	4 to 8	9+	Valid cases
	- - - - - - Percent	- - - - -		
High use week and area	92	0	8	12
Low-medium use week and area	67	23	11	84

Chi-square = 3.71 Significance = 0.16 Total cases = 126

Attitudes towards recreational use management practices favored measures that would protect the ANWR from degradation by maintaining wilderness and wildlife values. All facilities--trails, bridges, and aircraft landing areas--were unwanted. This is somewhat in contrast to the Rocky Mountain and Desolation Wilderness recreationists who accepted trails and bridges across dangerous rivers as necessities.

Shelby (1981) found little association between satisfaction and encounters on several western rivers, with factors other than encounters being more important in influencing satisfaction. In the ANWR, satisfaction appears to be associated with group and aircraft encounters; the level of association between group encounters and satisfaction is approximately the same as that of recreationists of the Rocky Mountains and Desolation Wilderness. Trip satisfaction for hunters was strongly associated with hunting success.

Several studies (Stankey 1973 and 1980; Heberlein 1977) have indicated that as use increases, the average recreationist's perception of excessive use is more lenient. Therefore, as recreation use increases, the people who still seek low-density opportunities and naturalness may be displaced to other areas, or may continue to visit an area for its recreational qualities rather than for its wilderness qualities. If management decisions are made for the ANWR that allow use to increase above maximum levels identified by strong and very strong purists, satisfaction in terms of a wilderness experience probably will decrease for the average strong and very strong purists. Satisfaction probably will not decrease as rapidly for the average recreationist of lesser purist groups. This would tend to displace the stronger purist recreationists to other areas, if available.

Relating recreationist's objectives to management objectives was accomplished in this study by differentiating purist groups. Very strong purists' perception of what constitutes acceptable human contact or resource quality can serve as a guide to desirable wilderness management approaches. The social element of limits of acceptable change for very strong purists may be met by limiting light aircraft sightings to three per week, in addition to their chartered, rented, or own aircraft. With decreased aircraft sightings there would be a corresponding decrease in the number of groups and aircraft landings sighted.

Information and education (I&E) program objectives for the refuge should be to inform recreationists of appropriate behavior and practices that will protect the area from excessive physical and social impacts. An I&E program may greatly decrease the need for more regulatory approaches to managing use. If managers decide that rationing is needed, the most favored permit system was limiting plane landings, and it would be the most acceptable to recreationists.

I recommend that future research further quantify the effects of encounters with groups and light aircraft. One specific recommendation is to determine whether, and to what extent, minimum altitude restrictions for light aircraft would decrease social impacts.

REFERENCES

Badger, T. J. Rawah wilderness crowding tolerances and some management techniques: an aspect of social carrying capacity. Fort Collins, CO: Colorado State University, 1975. 83 p. Thesis.

Dillman, D. A.; Christenson J. A. Increasing mail questionnaire response: a four state comparison. Am. Sociol. Rev. 30: 341-353; 1974.

Frissel, S. S. Jr.; Stankey G. H. Wilderness environmental quality: search for social and ecological harmony. In: Proceedings, Society of American Foresters annual meeting; Hot Springs, AR. Society of American Foresters; 1972: 170-183.

Heberlein, T. A. Density, crowding, and satisfaction: sociological studies for determining carrying capacities. In: Proceedings: river recreation management and research symposium; 1977 Jan. 24-27; Minneapolis, MN: Gen. Tech. Rep. NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 67-76.

Lime, D. W.; Stankey G. H. Carrying capacity: maintaining outdoor recreation quality. In: Proceedings recreation symposium; 1971 Oct. 12-14; Syracuse, NY. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1971: 174-184.

Lucas, R. C. Use patterns and recreationist characteristics, attitudes,and preferences in nine wilderness and other roadless areas. Res. Pap. INT-253. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 89 p.

Lucas, R. C.; Oltman J. L. Survey sampling wilderness visitors. J. Leisure Res. 3(1): 28-43; 1971.

Nielson, J. M.; Shelby B. River-running in the Grand Canyon: how much and what kind of use. In: Proceedings: river recreation management and research symposium; 1977 Jan. 24-27; Minneapolis, MN: Gen. Tech. Rep. NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 168-177.

Shelby, B. Encounter norms in backcountry settings: studies of three rivers. J. of Leisure Res. 13(2): 129-138. 1981.

Spetzman, L. A. Vegetation of the arctic slope of Alaska. Prof. Pap. 302-B. U.S. Department of the Interior, Geological Survey; 1959. 58 p.

Stankey, G. H. A comparison of carrying capacity perceptions among recreationists to two wildernesses. Res. Pap. INT-242. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 34 p.

Stankey, G. H. Recreationist perception of wilderness recreation carrying capacity. Res. Pap. INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 61 p.

Warfhatig, C. Physiographic division of Alaska. Prof. Pap. U.S. Department of the Interior, Geological Survey; 1965. 52 p.

Warren, G. A. Activities, attitudes and management preferences of visitors of the Arctic National Wildlife Range, Alaska. Moscow, ID: University of Idaho; 1980. 51 p. Thesis.

DISPERSED RECREATION USE AND USERS IN KOSCIUSKO NATIONAL PARK, AUSTRALIA: A PROFILE AND COMPARISON WITH THE UNITED STATES

George H. Stankey

ABSTRACT: Use and users in the Summit Area, an undeveloped portion of Kosciusko National Park in southeastern Australia, were compared with users in wilderness and wildernesslike areas in the United States. Users in both countries were young, predominantly male, resided close to the area visited, and were not members of organized conservation or recreation clubs. Most use characteristics were similar: short stays, small groups, and multiple activity participation. However, there were sharp differences in the evaluation of use conditions even though encounter levels were similar; United States visitors were much more concerned with crowding. Although use of wildernesslike areas appears similar in the two countries, perception of the meaning of these areas and their appropriate use and management appears mitigated by cultural influences.

INTRODUCTION

Leisure and recreation behavior represent a critical part of our social lives (Cheek and Burch 1976). Because these aspects of social life are influenced greatly by differences in cultural perception, we would expect to find significant differences in the way different cultures regard use of leisure time and resources and the meaning they attach to such engagements. For example, Hutchinson and Fidel (1984) reported differences between Mexican-American and Anglo groups in Chicago not only in terms of activities but also in the social composition of groups. Florian and Har-Evan (1984) found significant differences in choice of activities between Arabs and Jews residing in northern Israel. However, one would expect less cultural differences where the cultural origins are less distinct. Arndt and others (1980) reported that although there were differences in the average time spent in different leisure activities by Norwegians and Americans, the range of choice in leisure activities was "surprisingly similar," a finding they attributed to the fact that both countries are modern western societies that share basic cultural values. Similarly, Parker (1980) reported that differences in participation between the United States and Great Britain are less significant than the differences among socioeconomic groups within each country.

AUSTRALIA--AN OVERVIEW

At first glance, Australia and the United States share many things. Both share common Anglo-Saxon origins and are modern industrialized societies. The two countries are even approximately the same size if the conterminous 48 States are compared to the Australian continent. However, beneath some of these apparent similarities rest critical differences, especially in the nature of the Australian country and its people.

Australia is the smallest continent but the world's sixth largest country. Remoteness characterizes the country perhaps as well as any word and it applies both to the location of Australia relative to the remainder of the world and to areas within the country. Even traveling by jet, Australia is over a day's journey from Europe and 15 hours from the west coast of the United States. Its remoteness is embodied in its frequent referral as "the Antipodes," poles apart from the remainder of the world.

Australia is lightly populated; only 15 million people occupy its mass, with a resultant population density only one-twelfth that of the United States. Australia is highly urban. Seventy percent of the population resides in the six State capitals; two-thirds of the population live in a crescent running between Brisbane in the northeast and Adelaide on the south and within 80 miles (50 km) of the coast. In no other modern country is such a centralization of population found (McKnight 1970).

With such a population concentration, vast areas of Australia are absent of people. Distance, as Blainey (1966) noted, characterizes Australia as well as mountains characterize Switzerland. The dispersed nodes of population are connected by an extensive road system, but only about 10 percent of the rural roads are paved. Nevertheless, car ownership is second only to the United States and Australia spends a higher proportion of its total oil supplies running its private automobile fleet than any other country. Fully one-third of this travel is for leisure and recreation (Mercer 1981).

Along with low population and great distances, a third feature of Australia is its aridity. Australia has the smallest supply of surface

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water of any settled continent. Well over half of the country receives less than an average of 15 inches of rainfall annually. Moisture availability is a major limiting factor to the country's settlement and development.

Politically, Australia operates under the Westminster form of government. One important feature is that the States hold principal authority in the field of natural resource management, including national parks. As a result, there are seven separate national park authorities in Australia (six States plus the Commonwealth Government).

Characterizing Australian society is difficult. Most of what has been written is anecdotal and speculative. However, some serious, systematic efforts have been attempted. For example, Lipset (1963) compared Australian society to United States society, concluding that Australia was slightly more egalitarian, but less achievement oriented. Although the frontier plays an important role in the history of both countries (Alexander 1947), the character of the frontier produced quite different results. The generally foreboding nature of the Australian environment, especially its climate, helped produce a greater feeling of interdependence--the concept of mateship--among people than occurred on the United States frontier where there was greater opportunity for individual initiative.

Pearson (1977) concluded that egalitarianism appears to be the most distinguishing single value pattern characterizing Australians. He also concluded that it appears that hedonistic values are gaining ascendancy over the puritan code under which many older Australians were raised. He cited survey data that suggest that younger persons consider leisure to be more important relative to work than older persons.

There is also a certain element of fatalism in Australian society, embodied in the catch phrase "She'll be right." It is an attitude that promotes the notion that everything will work out on its own and that each person will take care of himself. It also seems linked to Lipset's observation of a generally lower level of achievement orientation among Australians than Americans (Lipset 1963).

These, as noted earlier, are generalizations about Australian culture, gleaned from a variety of writings and anecdotes. Although not systematic, they nevertheless help convey the idea that Australian culture is different, not just a southern hemisphere version of the United States'. And although the cultural settings are not dramatically distinct, there are important, often subtle differences regarding what we might call the "life view."

This certainly pertains in the case of wilderness. Like the North American pioneers, the early Australians found themselves confronted by a continent of wilderness. However, unlike the North Americans, early Australian inhabitants were unwilling settlers. Even in 1850, over half were convicts or relatives of convicts. The physical setting with which they were confronted was not only wild, but wholly different from anything previously experienced. But like the North American pioneers, they expressed an ambivalence of views, ranging from ". . . in the whole world there is not a worse country than what we have . . . seen . . ." to "to describe the beautiful and novel appearance . . . is a task I shall not undertake . . ." (Seddon 1976).

The concept of wilderness has not enjoyed the level of public support or the degree of sophistication in Australia that it has achieved in the United States. Interest is growing, however, and through efforts of organizations such as the Australian Conservation Foundation (ACF), national conferences, and local groups, public awareness and support are growing. Perhaps the most significant reflection of this was in the recent public protests to a proposed dam in the wilderness regions of southwest Tasmania. Civil disobedience, protest votes on ballots, and legal action were brought together to successfully protect the area's wilderness values.

The generally less-developed concept of wilderness is reflected in the relatively small amount of research and scientific literature dealing with wilderness. Only limited data exist, for example, about Australia's wilderness use and users and their attitudes, motivation, and behavior. One important exception is McKenry (1975), who surveyed both user and general population attitudes, concluding that users were similar in many respects to members of the community at large and that there was considerable latent support for wilderness preservation across the population. However, studies of use and users are only now beginning to be undertaken, typically as theses.

PURPOSE

In the absence of a literature dealing with Australian wilderness use, results from studies in the United States are often used in an effort to provide at least some basis for decisions. However, as suggested by the above discussion, transference of such data across cultural settings is not a simple, direct process, even when the cultural differences might not appear great. This study attempts to provide a better basis for judging the differences and similarities.

This paper reports on a study of the use and users in the Summit Area, an undeveloped portion of Kosciusko National Park in southeastern Australia. Although wilderness areas can be established in Australia (under State rather than Federal authority), the Summit Area is not so designated. Nevertheless, the management objectives prescribed for it call for preservation of the area's unique environmental features and provision of primitive recreational opportunities--objectives reminiscent of those established by the United States Wilderness Act.

But while the setting of the Summit Area is similar to that of many wildernesses in the United States, and its management objectives closely resemble those of the United States wilderness system, to what extent can inferences for management purposes be drawn between results of studies of United States areas and the situation in the Summit Area? Transferring experiences from one culture to another is fraught with problems. This is particularly the case with wilderness, a product of cultural evolution. Even though similar physical settings might be involved, can we assume that different cultures perceive, use, and lend meaning to them in similar ways? What variable meanings assigned to the respective settings confound our ability to generalize about their function in different cultures? And what concepts of appropriate use and management emerge from the different cultures?

Such questions face us as we attempt to understand the use and users of wilderness settings in different countries. In this report, we examine the similarities and differences between the users of a wildernesslike setting in Australia and their counterparts in the United States. Such an analysis is intended to shed light on the extent to which such settings share similar clientele and provoke common behaviors in their respective cultural settings and to appraise the extent to which approaches to use management might be mutually applicable.

STUDY AREA

The Summit Area comprises an alpine/subalpine region in the southern portion of Kosciusko National Park in southeastern New South Wales, Australia. It is managed by the New South Wales National Parks and Wildlife Service. The Summit Area encompasses approximately 62,000 acres (25 000 ha), about 4 percent of the total Park, and is roughly centered on Mount Kosciusko, at 7,350 feet (2 228 m) the highest point on the Australian continent (fig. 1).

Figure 1.--Location of Kosciusko National Park, New South Wales, Australia.

The Summit Area has long been a focus of interest. The presence of the country's highest peak and year-round snow in mostly arid country are major attractions. In 1906, a road to the summit of Mount Kosciusko was built. By 1973, traffic levels had grown to the point that congestion along the road and at parking areas was severe. Extensive use of adjoining alpine areas also led to a proliferation of eroding trails leading to the summit of Mount Kosciusko.

To contend with such problems, a variety of solutions were attempted. Private vehicle use was banned from the Summit Road in 1974 and replaced by a private subsidized shuttle system from Charlottes Pass (fig. 2). Major programs of trail construction and erosion control measures were initiated; most proved unsuccessful. The shuttle service was abandoned in 1981 and the 1982 plan of management called for rehabilitation of the Summit Road to a walking trail.

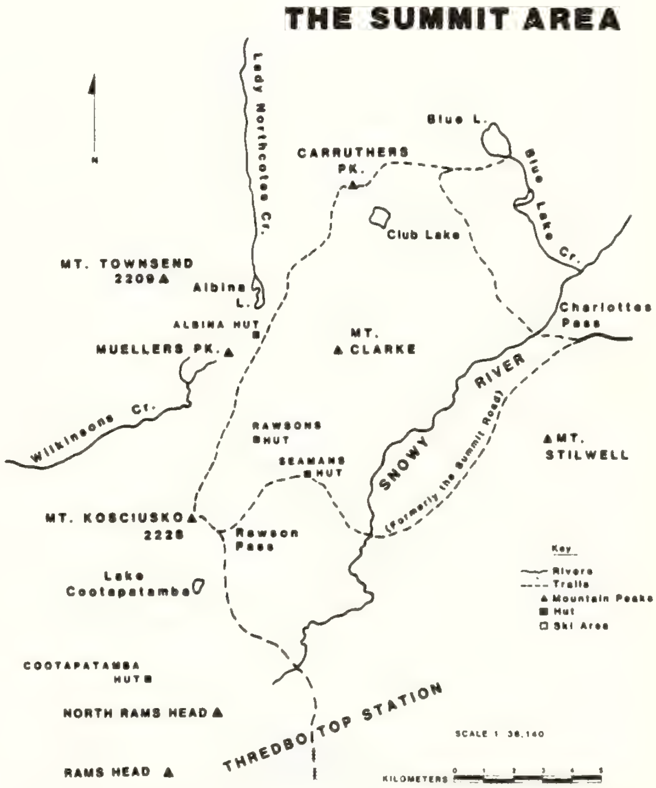

Figure 2.--The Summit Area portion of Kosciusko National Park.

A major ski development lies along the southeastern edge of the Summit Area, and ski lifts provide access to the area during both winter and summer (fig. 2). Access is also easily achieved from the Charlottes Pass road on the northeast. Thus, the generally undeveloped and ecologically sensitive area is vulnerable to probable steady growth in recreational use.

Management of Kosciusko National Park in general and the Summit Area in particular has been of major interest to the public. Over 700 submissions were received in response to a draft plan of management. The area's unique physical qualities (the alpine setting, permanent snow fields, the nation's highest peak), its symbolic importance as the home of The Man from Snowy River, and its location close to the capital cities of Sydney, Melbourne, and Canberra all combine to make management a matter of great public interest.

Conflict between the environmentally sensitive Summit Area and the growing recreational pressures upon it is brought into focus by the prescriptions established in the 1982 plan of management for Kosciusko National Park. These prescriptions stress preservation of the unique environmental assemblage found in the area; at the same time, recreation is also a legitimate use. However, lack of information about the area's use and users handicaps the manager's ability to effectively meet area objectives.

STUDY METHODOLOGY

The study analyzed responses to a questionnaire mailed to overnight and day users of the Summit Area during the summer (southern hemisphere) of 1982-83. Names and addresses for the survey were obtained from cards placed in unmanned registration boxes at the area's three primary entrances. All persons 16 years and older were asked to complete a card. Because voluntary registration systems had not been used widely in Australia, compliance was checked by unobtrusive observation at each entrance on selected days. Overall compliance was 63 percent.

The study began in mid-November 1982 and continued until mid-February 1983. An interval sample of 1,168 individuals was drawn and a booklet-format questionnaire mailed, along with a franked return envelope. Two weeks after the initial mailing, a reminder with another questionnaire was mailed. Overall, 921 usable forms were returned, a 79 percent return rate. No test of nonresponse was made; nor can an assessment of the implications of the nonregistration, nonresponse bias be made.

CHARACTERISTICS OF RECREATION USERS

Four variables concerning visitor characteristics were collected--age, sex, residence, and membership in a conservation or outdoor recreation club.

Age

As table 1 indicates, most respondents were in the younger age brackets; nearly half were less than 30 years old. As age increases, the proportion of visitors in the age categories declines relative to the Australian population.

Table 1.--Age distribution of respondents and the Australian population[1]

Age category	Summit Area respondents	Australian population[2]
15-19	[3]11.9	12.4
20-24	18.1	11.4
25-29	16.4	11.2
30-34	12.9	10.1
35-39	12.5	8.3
40-44	8.9	7.4
45-49	5.4	7.5
50 and over	13.6	31.9

[1]Based on persons 16 years or older, including Australian population percentages.

[2]Based on estimated age distribution June 30, 1977, as reported in Yearbook Australia 1979, p. 80.

[3]In this study, only persons 16 and over were asked to register; therefore, the age comparison with the general population is not directly comparable.

Nearly one-third of the Australian population is over 50, compared to about 14 percent of the surveyed population. However, a wide range of age groupings is found recreating in the Summit Area, and it is clearly not just a setting for the young.

The pattern of age distribution is not wholly dissimilar from that in the United States. Table 2 compares results from the Summit Area with those from Lucas (1980). (Lucas' age groups differ somewhat and are shown in parentheses.)

Table 2.--Pattern of age distribution, Summit Area compared to United States

Age group	Summit Area	Lucas
	Percent	
15-19 (16-20)	12	19
20-24 (21-24)	18	12
25-34 (25-34)	30	25
35-44 (35-44)	22	21
45 and older (45 and older)	18	23

$X^2 = 18.32$, 4 df, $p = 0.01$

Sex

About 60 percent of the respondents were male. Because everyone over 16 years of age was asked to register, there should not be any significant bias introduced into the sex composition of the groups (for example, a request that party leaders only register typically introduces a male bias).

Males accounted for about 70 percent of the overnight campers and nearly 60 percent of the day users. The relatively limited participation of women, particularly among those camping, is not dissimilar from figures reported in studies in the United States. A recent analysis of use trends in the Bob Marshall Wilderness complex by Lucas (1985) reports that female participation grew from 20 percent in 1970 to 30 percent in 1982. Whether a similar trend is operating in Australia is not known, but the role of women in Australian culture is still that of a minority group and only recently have women begun to make gains in the workforce and in positions of responsibility. Their role in Australia, as in the United States, is one of striving to attain equality, but their present achievement likely trails that found here.

Residence

Postcodes were used to code respondent residence. The area draws its use primarily from New South Wales and the Australian Capital Territory (A.C.T.); three out of four visitors reside in these areas. An additional 15 percent come from Victoria.

The local origin of most visitors closely mirrors the situation in many North American wildernesses. Lucas (1980) reported that persons visiting a wilderness who resided in the same State as the area accounted for from 53 to 93 percent. Sydney, with 3 million people, and Canberra, with a quarter million, are both within a day's drive.

Membership in Conservation or Outdoor Recreation Clubs

Joining a conservation or outdoor recreation club is one way people can express their interest and commitment, either to a type of activity such as hiking (or its Australian equivalent, bushwalking), or to a concept such as nature preservation. Respondents were asked whether they belonged to any such organizations and a tally of the number of such organizations was made.

Thirty percent of the respondents belonged to conservation or outdoors groups. This closely matches results found in studies of backcountry and wilderness users in the United States (Stankey 1973; Lucas 1980, 1985). Among those who belong to an organization, 61 percent were a member of only one organization, 24 percent belonged to two, and 15 percent belonged to three or more. Over 200 different organizations were listed, ranging from major conservation groups such as the ACF (Australian Conservation Foundation) and National Parks Association, to local garden and sporting groups. This multiple membership also mirrors the situation in the United States; Lucas (1980) reported that one-third of those belonging to a club were members of two or more such groups.

CHARACTERISTICS OF THE RECREATION VISIT

Respondents were asked to provide information about the trip on which they had been sampled. Variables examined in this section included party size, type of group, length of stay, and recreational activities in which they participated.

Party Size

Small groups are clearly the norm. As table 3 indicates, one-half of the parties have three or fewer members. However, few recreate in the area alone; only 4 percent travel by themselves. Few travel in larger groups either; only 9 percent of all parties had over 10 members. Overnight campers tended to travel in these larger groups.

Table 3.--Party size distribution for day users and campers in the Summit Area (percentage)

Party size	User group: Day users	Campers	Total	Average
N	720	157	877	
1	3	8		4
2-3	47	43		46
4-5	28	20		27
6-9	13	15		13
10 and over	8	14		9

$X^2 = 18.52$, 4 df, $p = 0.001$

Twenty-nine percent of the campers were in parties of six or more compared to 21 percent of the day users. Still, it is clear that the norm is one of smaller groups. These figures mirror those reported in studies not only of similar recreationists in the United States, but in other recreation activities as well, clearly emphasizing the social nature of recreation behavior.

Type of Group

Respondents were asked whether they were traveling by themselves, with family, with family and friends, or with an organized group. An equal percentage of parties were families or families and friends traveling together (42 and 43 percent, respectively). Another 11 percent reported traveling with an organized group, such as Scouts. Lucas (1985) found a generally similar pattern with slightly over 90 percent of the parties composed of families and/or friends, but only about 3 percent with clubs or organizations.

Length of Stay

Day use predominates in the Summit Area. Eighty-two percent of all visits involved less than a 1-day stay; only about 3 percent stayed more than 2 nights. Among those camping, one-half were out for only 1 night and only about 10 percent stayed 4 nights or longer.

The length-of-stay figures in the Summit Area contrast sharply with those reported by Lucas (1980). He reported a range of 1.3 to 5.7 days, with length of stay generally related to area size. However, he also noted that registration compliance by day users is typically poor and, consequently, his figures might overstate average length of stay. Many areas in the United States are used on a predominantly day basis, especially those close to population centers (Hendee and others 1978). The difference might also reflect a cultural difference in attitudes toward primitive camping. Mercer (1981) reported that, based on data for camping equipment imports into Australia between 1971 and 1978, camping grew at an annual average rate of 256 percent. This tremendous rate is suggestive of the early component of activity growth, when absolute levels are low. Such a growth rate will likely stabilize later. Growth rates for primitive camping in the United States are approximately 3 to 5 percent per year.

Recreational Activities

Respondents were presented a list of common recreational activities and asked to indicate which, if any, they had done. The results, comparing the response of day users and overnight campers, are presented in table 4.

In general, both groups had similar patterns of recreational activity participation. Rock climbing was one exception, with campers about twice as likely to engage in it as day users. This likely reflects the time required to reach suitable climbing areas, carry out the activity, and return. Campers were also somewhat more likely to report "other activities." Approximately 20 percent of these responses cited bush-walking, hiking, or backpacking. The remainder were spread over a range of activities including socializing with friends, playing in the snow, and swimming.

Table 4.--Summit Area day user and camper participation rates in selected activities (percentage)

Activity	User group: Day user	User group: Camper
N	754	161
Photography	71	70
Fishing	4	3
Nature study	39	34
Rock climbing	9	18
Sightseeing	91	83
Relaxation	70	71
Other	21	32

Most people indicated they engaged in more than one activity; the mean number of activities checked was 3.2. This multiple activity pattern is similar to recreation activity patterns in similar recreation areas in North America; Lucas (1985) reported an average of 2.6 activities. Few people go to such areas with only one purpose in mind.

The pattern of recreational activities reported by Lucas (1985) closely resembles that found in the Summit Area. Just over 60 percent of the Lucas sample participated in photography and nearly 30 percent engaged in nature study. However, there was a sharp difference in fishing activity; about 4 percent of the Summit Area visitors reported it, while nearly 60 percent of their United States counterparts fished. This difference is due in part to the relative scarcity of fishing opportunities in the Summit Area (some sport species have been introduced in area rivers and lakes) and to the generally lower level of fishing activity in Australia. Mercer (1981) reported a 5 percent decline in license sales from 1974 to 1978, with another predicted 1 percent decline in the period 1978-85. There is, of course, an interaction between the limited supply and the low level of expressed demand; the very limited surface waters in Australia mean that few opportunities exist for freshwater fishing as a recreational activity.

VISITOR EVALUATION OF CONDITIONS

Based on discussions with area managers, a series of questions was developed to determine visitor recognition and evaluation of area conditions. Several areas were identified; here we examine the number of other parties encountered and the evaluation of them.

Number of Other Parties Encountered

While the quality of solitude might be typically used to describe the Summit Area, it is clear that most visitors do not escape from one another. Both day users and campers report fairly high levels of contact with others; conversely, hardly anyone reported seeing no others (table 5).

Table 5.--Number of encounters reported by day users and campers in the Summit Area (percentage)

No. of parties encountered	User group: Day user	Camper	Total	Average
N	632	148	780	
0	<1	1		<1
1-2	4	5		4
3-4	8	16		9
5-6	15	16		15
7-10	18	15		18
11-15	9	11		9
16-25	10	12		10
26 and over	12	10		12
Adjective description ("few," "many")	24	15		22

$\bar{X} = 13.2$, S.D. = 8.5, $X^2 = 8.8$, 7 df, $p = 0.20$

Contact levels are high in the Summit Area. One-half of the groups reported seeing seven or more parties per day, and the mean number of contacts was over 13. The open character of the landscape, coupled with the fact that most users travel along established trails, contributes to this situation. There was no significant difference in reported encounters between day users and campers.

Whether these encounter levels represent too few or too many is not self-evident, however. Such an evaluation is a matter of personal judgment reflecting individual values, preferences, and expectations. Respondents were asked to indicate whether the number they had encountered represented "too many," "too few," or "about right." A "no opinion" category was also included. The results are shown in table 6.

Most respondents reported the level of encounters as being about right. Overall, about one in five reported the level of use they encountered as too many, and an equal number said they had no opinion. Less than 5 percent described the contact level as being too few.

Table 6.--Reaction to number of other parties encountered by day users and campers in the Summit Area (percentage)

	User group: Day user	Camper	Total	Average
N	735	156	891	
Too many	17	22		18
About right	58	53		57
Too few	5	3		4
No opinion	21	22		21

$X^2 = 4.5$, 3 df, $p = 0.30$

The high level of "about right" responses suggests most visitors were satisfied with the encounters they experienced. However, most studies in the United States report that visitors express satisfaction with the encounter levels they experience in an area (see the state-of-knowledge review paper by Stankey and Schreyer, this proceedings). There are a variety of reasons for this. Recreation is a voluntary, self-selected behavior and it follows that most people tend to choose activities and settings in accord with their judgment of what constitutes "a good time" (Shelby 1980). In other cases, persons who once used an area because of low contact levels might now have moved on, replaced by others attracted, or at least not put off, by higher contact levels. Or, in the face of higher than desired contact levels, visitors might simply make the best of the situation, focusing on other experiences.

There could also be a culturally based explanation. As noted earlier, Australian culture is characterized by a tendency to accommodate life as it comes. Moreover, the relative scarcity of opportunities such as are found in the Summit Area likely contributes to a tendency to accept use conditions as they are. Compared to the other benefits provided in such a unique area, encounter levels take on a relatively low priority, at least within reason.

The results from tables 5 and 6 were compared with results from the Desolation Wilderness in California (Lucas 1980). Converting the total number of encounters shown in table 5 to the average-per-day figure for campers to the Summit Area (whose average length of stay was just under 2 days), we can compare with Lucas' results, as shown in table 7.

These data indicate that while encounter levels in the two areas are not significantly different (as reflected by the average number of daily contacts reported), visitor evaluation does differ significantly. Summit Area visitors do not appear to attach as much importance to solitude as Desolation Wilderness visitors. Moreover, there is a greater degree of indifference, either in the form of a legitimate inability to state an opinion or in the equally legitimate belief that it simply doesn't matter.

Table 7.--Average number of other parties met per day and opinions of the number met, for visitors to the Desolation Wilderness, California, USA, and the Summit Area[1]

	Desolation Wilderness	Summit Area
Average Number Met Per Day		
0	9	12
1-3	45	44
4-10	30	31
11-20	10	3
Over 20	6	10
$X^2 = 6.1$, 4 df, $p = 0.20$		
Opinion of Numbers Met		
Too few	2	3
About right	42	53
Too many	48	22
No opinion, other replies	8	22

$X^2 = 33.6$, 3 df, $p = 0.001$

[1]Summit Area includes overnight campers only.

It is also important to consider that the above comparison might not involve directly comparable populations. Although a large, undeveloped area, the Summit Area is not legally classified as wilderness and its appeal is not solely as a locale for avoiding the presence of others; it is also site of the country's highest peak, and it is convenient. These data remind us of the need for caution when interpreting perceptual judgments derived from one cultural context and applying them to another.

DISCUSSION AND SUMMARY

Recreational use in the Summit Area has many similarities with its counterpart in wilderness and dispersed recreation settings in the United States. Users in both countries are drawn disproportionately from the 25-44 age categories. However, both countries are also similar in that the declining birth rate is leading to a generally aging population. By the turn of the century, it is projected that 11 percent of the Australian population will be over 65, up from about 9 percent at present, and the under-15 category will decline from about 26 percent to under 23 percent (Australian Bureau of Statistics 1979; Mercer 1981).

The implications of this shift in age structure suggest some decline or at least slowing in the rate of growth in demand for primitive recreation settings. Although trend data are generally lacking, the growth in bushwalking (hiking) for the State of Victoria has been estimated at a rate of 7 percent annually for the period 1970-75 and projected at a rate of 2 percent annually for the period 1978-85 (Mercer 1981).

However, countering the general decline in participation with age is the effect associated with persons who have participated in and learned about certain activities as young people. As these people enter the so-called "young-old" category (55-75 years), the effects of this earlier learning and socialization might operate to reduce the impacts otherwise associated with increasing age (Neugarten 1974). Although participation rates will likely decline in wilderness and related activities as Australia's median age rises, we must also be aware that the political awareness and activity of this group with regard to wilderness preservation and management likely will not diminish. In fact, it is plausible that it might rise as people replace their direct participation with vicarious involvement on the political front.

Female participation in both countries was low, but is on the increase in the United States (Lucas 1985). Although it is not possible to draw a direct causal linkage between such growth and the women's rights movement in either country, it seems plausible that the increasing recognition of women's rights in other sections of society will be mirrored in their participation in leisure and outdoor recreation as well. As noted earlier, the women's rights movement is much less well developed in Australia, and it is unclear as to whether a major increase in female participation will occur, at least in the near future.

Finally, users in both countries share two important characteristics from a management perspective. The bulk of users live within a 1-day drive of the areas where they recreate. Therefore, management efforts to communicate with users, particularly before they arrive onsite, can be targeted relatively efficiently by channeling information through regional media. Additionally, both populations display an almost identical proportion who are members of organized conservation or outdoor recreation groups, even though voluntary association membership in Australia is significantly lower than in the United States (Pearson 1977). This is an important group with whom managers need to work; they are likely opinion leaders and are actively concerned with the area's management. However, public contact programs must be directed beyond these formal groups; two out of three users are unaffiliated and will require expanded efforts to be reached with information about area management, rules, and regulations.

The group structure of recreation participation in the Summit Area mirrors the situation found in the United States; few people travel alone. As Field and O'Leary (1973) suggested, the

social group rather than the individual characterizes most recreational settings and gives those settings meaning. Although such groups are subject to a variety of influences, their function appears to transcend the cultural differences involved here.

The profiles of length of stay, recreational activities, and use patterns in the Summit Area reflect great similarity with United States profiles. Although the Summit Area is characterized by greater day use than most dispersed recreation areas in the United States, the difference is more of degree than of kind. Indeed, within the variety of dispersed settings in the United States, as much intra-area difference can be found as was reported in this interarea comparison. Also, the differences can be accounted for by individual area characteristics. The Summit Area is readily accessible, and, as a consequence, receives heavy day use, heavy concentration of use along a few routes, and short trips. Such characteristics are similar in the United States where similar access conditions prevail (Lucas 1980; Stankey 1973).

The multiple activity pattern reported by users in both countries strongly supports the idea that recreation is a source of multiple satisfactions (Hendee 1974), driven, in part, by multiple motivations (Driver and Brown 1975).

However, the general pattern of similarity between the Summit Area and United States areas does not persist when we examine the perception of use levels. Although reported levels of daily encounter were not sharply dissimilar when compared with a study of Desolation Wilderness users (84 percent of the Desolation users encountered up to 10 other parties per day, compared to 83 percent of the Summit Area users), evaluations of these encounters were quite different. The differences primarily occurred not in terms of whether the number of contacts was "too few" or "about right," but in terms of whether it was "too many" or "no opinion." Several explanations seem plausible.

First, over twice as many Desolation users reported the number of encounters as "too many" (49 percent versus 22 percent), even though the reported encounter levels were similar. This might reflect a much more crystallized norm of appropriate use among Desolation users as opposed to Summit Area users (Shelby 1980). The conception of wilderness in the United States, the lengthy history of the idea, and its refinement and eventual institutionalization, as discussed by Nash (1982), do not have a parallel counterpart in Australia. As a result, Australian public conception even among regular users is not characterized by as crystallized an image as we find in the United States.

A second explanation focuses on a broad cultural norm of noninvolvement. In Australia, tolerance of others is part of the complex national character (Pearson 1977). There seems to be a much greater tendency to accept the behavior of others and to let others cope with events as they will. The "She'll be right" philosophy suggests a tendency to let things work out naturally, avoiding the need to intervene or impose outside solutions. The percentage responding "no opinion" regarding the number encountered is suggestive of this; one out of five Summit Area users so responded, compared to only one out of 10 Desolation users. The crystallized norm explanation, outlined above, complements this explanation.

Third, the response to encounter levels in the Summit Area might reflect individual coping strategies developed to contend with the high use levels. Unfortunately, no data on preferred use levels were obtained. However, it is entirely plausible that the response to the use levels encountered in the Summit Area might be analogous to the reports of satisfaction levels reported in many United States studies where actual encounters in excess of expressed preferences did not diminish satisfaction. Summit Area visitors might prefer lower contact levels, but in the face of greater than desired contacts, cope with them by employing strategies of acceptance or indifference. Unreported data from this study confirm virtually identical rankings assigned to such psychological outcomes as "being alone" and "being where it is quiet" between the two populations. The differences between the two populations might lie less in what is desired and more with how discrepancies between what is desired and what is encountered are handled.

Finally, the urban origins of the bulk of the Summit Area visitors might also contribute to the generally high level of acceptance of or indifference to others. Norms formed to deal with the high levels of interaction and contact common in urban settings (Milgram 1970) might also form the basis from which contacts in other settings are evaluated. Although it is true that most United States wilderness visitors also come from urban areas, the popular conception of wilderness as solitude in the United States likely supports a more discriminating set of norms regarding contact with others.

Interest in wilderness protection and use is growing in Australia (Mercer 1981), a phenomenon confirmed by the increasing level of governmental activity, use figures at parks, and equipment sales. Many of the reasons for this growth parallel those typically offered to explain growth in the United States: more money, more time, more mobility. Like the United States, Australia can expect to see increasing use of wilderness and political support for its protection.

While the United States experience is seen as a valuable aid, one from which much can be learned, there is also a recognition that the Australian situation--its geography, society, and legal and political institutions--is different and will require different solutions.

Subtle cultural distinctions suggest that wilderness management in Australia must evolve its own course.

REFERENCES

Alexander, Fred. Moving frontiers: an American theme and its application to Australian history. Port Washington, NY: Kennikat Press; 1947. 48 p.

Arndt, J.; Gronmo, S.; Hawes, D. K. Allocations of time to leisure activities: Norwegian and American patterns. Journal of Cross-Cultural Psychology. 11: 498-511; 1980.

Australian Bureau of Statistics. Yearbook Australia 1979. No. 63. Canberra, A.C.T.: Commonwealth Government Printer; 1979. 730 p.

Blainey, Geoffrey. The tyranny of distance. New York: St. Martin's Press; 1966. 365 p.

Cheek, N. H.; Burch, W. R. The social organization of leisure in human society. New York: Harper and Row; 1976. 283 p.

Driver, B. L.; Brown, P. J. A social-psychological definition of recreation demand, with implications for recreation resource planning. In: The Committee on Assessment of Demand for Outdoor Recreation Resources, Assembly of Behavioral and Social Sciences. Assessing demand for outdoor recreation. Washington, DC: National Academy of Sciences; 1975: 63-88.

Field, Donald R.; O'Leary, Joseph T. Social groups as a basis for assessing participation in selected water activities. Journal of Leisure Research. 5(2): 16-25; 1973.

Florian, Victor; Har-Evan, Dov. Cultural patterns in the choice of leisure time activity frameworks: a study of Jewish and Arab youth in Israel. Journal of Leisure Research. 16(4): 330-337; 1984.

Hendee, John C. A multiple-satisfaction approach to game management. Wildlife Society Bulletin. 2(3): 104-113; 1974.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Miscellaneous Publication No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Hutchinson, Ray; Fidel, Kenneth. Mexican-American recreation activities: a reply to McMillen. Journal of Leisure Research. 16(4): 344-349; 1984.

Lipset, Seymour Martin. The first new nation. New York: Basic Books, Inc.; 1963. 366 p.

Lucas, Robert C. Use patterns and visitor characteristics, attitudes, and preferences in nine wilderness and other roadless areas. Research Paper INT-253. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 89 p.

Lucas, Robert C. Use patterns, visitor characteristics, and attitudes in the Bob Marshall Wilderness complex, 1970-82. Research Paper INT-345. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985. 32 p.

McKenry, Keith. Recreation, wilderness and the public. Melbourne: Department of Youth, Sport and Recreation; 1975. 214 p.

McKnight, Thomas L. Australia's corner of the world: a geographical summation. Englewood Cliffs, NJ: Prentice-Hall; 1970. 115 p.

Mercer, David. Trends in recreation participation. In: Mercer, David, ed. Outdoor recreation: Australian perspectives. Melbourne: Sorrett Publishing; 1981: 24-44.

Milgram, Stanley. The experience of living in cities. Science. 167(3924): 1461-1468; 1970.

Nash, Roderick. Wilderness and the American mind. 3d ed. New Haven, CT: Yale University Press; 1982. 425 p.

Neugarten, B. L. Age groups in American society and the rise of the young-old. Annals of the American Academy of Political and Social Science. 415: 187-198; 1974.

Parker, Stanley. Leisure and leisure studies in the United States and Great Britain--a comparative study. Leisure and Society. 3(2): 268-276; 1980.

Pearson, Kent. Leisure in Australia. In: Mercer, David, ed. Leisure and recreation in Australia. Melbourne: Sorrett Publishing; 1977: 25-34.

Seddon, George. The evolution of perceptual attitudes. In: Seddon, George; David, Mari, eds. Man and landscape in Australia. Canberra: Australian Government Publishing Service; 1976: 9-17.

Shelby, Bo. Crowding models for backcountry recreation. Land Economics. 56(1): 43-55; 1980.

Stankey, George H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 61 p.

CERTIFIED WILDERNESS TRIP LEADERS: THEIR KNOWLEDGE LEVELS, SAFETY RECORDS, AND OPINIONS OF CERTIFICATION COURSES

David Cockrell, David Detzel and Sandra L. Braun

ABSTRACT: This study examined the reactions of Wilderness Education Association graduates to their outdoor leadership certification courses. Graduates were quite satisfied with their courses and instructors. Knowledge levels of graduates about conservation practices and especially outdoor safety were low, however, and only about four of 16 W.E.A. curriculum areas were implemented into graduates' subsequent programs.

INTRODUCTION

In 1940, J.V.K. Wagar pointed out that "the woods are filled with folk with no idea of woods sanitation, care with fire, or outdoor good manners" (Wagar 1940, p. 492). He suggested a bold strategy to address the problem:

> We need something which will definitely mark and reward those with experience and wisdom in outdoor living, resourcefulness in outdoor emergencies, and with acceptable standards for outdoor conduct . . . We need, in short, a certification of outdoorsmen.

The idea has never caught on in a big way, but it has never died either. At a recent conference on outdoor recreation user fees, LaPage (1984) acknowledged that certifying all hikers and backcountry users would be impractical, but he revived the suggestion that a license may be needed to test the competencies of outdoor group leaders.

There are essentially two major arguments in favor of certifying wilderness users and outdoor leaders. First, the current trend toward challenge and risk in wilderness use (Darst and Armstrong 1980) is associated with increasing numbers of accidents. Traditionally, the public has paid for the rescue of persons injured during such activities (Petzoldt 1974). McAvoy and Dustin (1981) proposed the controversial alternative of requiring recreationists to arrange their own rescues, but even if this suggestion were implemented the problem would be far from solved. Certification of wilderness users with demonstrated good judgment and knowledge of emergency procedures would provide an additional tactic to help prevent accidents.

Second, there is a growing sensitivity to the ecological impacts of wildland recreation. Cole (1979, 1982) has shown that extremely light use accounts for much of the impact. Studies by Miller and Miller (1979) and others have shown the painstaking efforts necessary to rehabilitate impacted wilderness soils, vegetation, and wildlife populations. On the other hand, studies of wilderness education (for example, Fazio 1979; Bradley 1979) have shown considerable success in changing the practices of wilderness users. It now seems clear that prevention of impacts through light-handed educational contacts is preferable to more heavy-handed use restrictions or to rehabilitation. Certifying the competence and knowledge of wilderness users about minimum impact use practices would serve to formalize and standardize the educational process.

This study examines the reactions of Wilderness Education Association graduates to their outdoor leadership certification courses. Graduates' satisfaction with the courses and opinions of the course objectives, instructors, and evaluation procedures are reported, as well as graduates' knowledge levels concerning standard safety and minimum impact use principles. Changes in precourse to postcourse evacuation and rescue records are also reported for graduates who have led formal outdoor groups. Finally, the study reports the extent to which W.E.A. curriculum elements are standardized into the graduate's subsequent leadership activities.

Support for certification among users is mixed. In several studies, "merit" has been addressed as an alternative system of rationing wilderness use. Merit is similar to certification in that permits are allocated on the basis of some demonstrable skill, knowledge, or past behavior (Shelby and others 1982). Shelby and his colleagues examined the preferences of backpackers and river runners for five allocation techniques: pricing, reservations, lotteries, queing, and merit. Sixty-six percent of the backpackers and 37 percent of the river runners felt that a merit system would not affect them. Fewer than 40 percent saw merit as a fair system, and none of the samples in their study gave merit majority support for acceptability.

Stankey and Baden (1977) were somewhat more supportive of merit systems. They identified reduced per capita impact, reduced overall use

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levels, and increased appreciation of the recreation opportunity as important benefits of merit systems. They felt merit would be accepted by users if it were seen as an alternative to more authoritarian rationing measures. In general, however, reactions of users might be described as guarded and attitudes of managers as hesitant.

The picture is currently being aggravated by a growing number of organized educational, therapeutic, and recreational user groups. In universities alone, Hendee and Roggenbuck (1984) found 542 courses which addressed wilderness in some way. Sixty-seven percent reported wilderness appreciation and use as the first or second main course objectives and 59.4 percent actually took classes on trips into wilderness areas. This population barely touches the substantial number of organized user groups represented by the Association of Experiential Education, the American Camping Association, Boy Scouts of America, and many regional outdoor education associations. The activities of such groups have become sufficiently noticeable that Young (1985) has suggested organized camps voluntarily ban their own groups from using classified wilderness. Perhaps an alternative would be to require that organized group leaders (rather than all users) be certified as safe, knowledgeable about conservation practices, and in possession of good judgment.

Support for certification among professional outdoor educators is also mixed. Ewart and Johnson (1983) elicited support for certification from 71 percent of a nationwide group of prominent outdoor educators (n = 54), but they found little agreement about the appropriate mechanisms for accomplishing it. Senosk (1977) found 30 percent of 148 U.S. outdoor pursuits organizations to use some licensing process in 1976, while 52 percent expressed a need for such a system. In Ontario, 76 percent of the Council of Outdoor Educators of Ontario supported development of a provincial certification scheme (Cousineau 1977). In Virginia, 70 percent of the Virginia Council for Outdoor Adventure Education supported a statewide system (Cockrell 1985). Cockrell also found that supporters of certification were significantly less often certified themselves or employed in professional outdoor leadership.

THE WILDERNESS EDUCATION ASSOCIATION

Given the mixed support among user groups, Petzoldt (1974) proposed a strategy for implementation of a certification scheme that was nearly as bold as Wagar's (1940) seminal idea:

> Many people feel that the possibility of restricting use of the wild outdoors to those who know how to conserve it is beyond political or public acceptance. I disagree. If informed people will take action, such a plan could be implemented. This means: A national organization that would provide for the education and certification of outdoorsmen (Petzoldt 1974, p. 228).

In 1976 the first formal outdoor leadership certification courses were offered by Petzoldt's Wilderness Education Association (W.E.A.). The organization offers a National Standard Program for Outdoor Leadership Certification (N.S.P.O.L.C.), taught through several formats. The N.S.P.O.L.C. is a typically 36-day standard course which employs wilderness travel and adventure activities to accomplish educational objectives in 17 major curricular areas. W.E.A. states that a certified graduate is able to do the following:

1. Teach others how to use and enjoy the wilderness with minimum ecological impact.
2. Safely lead others in the wild outdoors.
3. Exercise good judgment in a variety of outdoor environments and conditions.
4. Demonstrate a basic standard of outdoor knowledge and experience.

Through the N.S.P.O.L.C., W.E.A. hopes to reach its overall goals of maximizing the opportunity for people to safely enjoy wild outdoor areas and minimizing man's impact on those areas. In 1984, the certification courses were taught out of the home office in Idaho and 23 affiliating universities in the U.S. and Canada. More complete descriptions of the W.E.A. philosophy and program are provided by Petzoldt (1984) and Cockrell and LaFollette (1985).

The Wilderness Education Association has therefore actually implemented the "certified outdoorsman" idea proposed by Wagar (1940) and discussed for 45 years. Now, nearly 10 years after the inception of the program, it should be asked how well certification has worked. Who, for example, has chosen to seek certification: private users with only recreational aspirations, or professional outdoor leaders? The organization's target audience has varied, and students are a largely self-selecting sample. Do W.E.A. graduates feel that the program's objectives have been met, that they were evaluated fairly, and that their instructors were capable? Are the graduates knowledgeable about outdoor safety issues and minimum impact use practices? Are their leadership activities actually safer after their training? Are they using the W.E.A. curriculum material as a basic standard in their own programs? This study offers an exploratory effort to address these difficult questions, and begin to understand the benefits and problems of a current certification system.

METHODS

The population for this study consisted of the 648 graduates of W.E.A. certification courses from the first course in 1976 through those completing courses in 1983 (n = 648). Two third-class mail questionnaires and a first class follow-up were sent to the entire population. Two hundred sixty-one graduates returned usable questionnaires for a response rate of 41.1 percent.

A nonresponse bias telephone survey was conducted with a sample of 74 nonrespondents to the mail questionnaire. Thirty-five of these nonrespondents (47 percent) were unreachable through W.E.A. addresses or telephone directory assistance. No significant differences were found between questionnaires from respondents and completed interviews with 27 nonrespondents on course satisfaction, degree to which course objectives were met, fairness of course evaluation techniques, or percent employed in outdoor leadership prior to the W.E.A. course. The low return rate in the study was attributed to incorrect addresses caused by the high mobility of outdoor leaders.

The main instrument used was a 32-question, four-part mail questionnaire. Subjects evaluated their W.E.A. courses on Likert-type scales measuring satisfaction with the course, degree to which 16 course objectives were met, fairness of their performance evaluation, and capability of their instructors on 10 instructor effectiveness measures.

Five multiple choice items measured knowledge of W.E.A. standard safety practices, and five similar items measured knowledge of minimum impact use practices. The knowledge questions were developed from the W.E.A. curriculum outline. A draft of the scales was reviewed by a panel of "experts" (two W.E.A. instructors, the associate director of W.E.A., and one member of the W.E.A. board of trustees). A revised draft was then pilot tested with 29 graduates of the Virginia Tech affiliate W.E.A. course. Based on the pilot test, one of the 10 knowledge questions was considered ambiguous and replaced. Three questions were reworded to increase clarity, and distractors were replaced on two others to increase difficulty. The final scale was considered to be a content valid sample of information taught in the W.E.A. standard curriculum.

Self-report measures were used to assess the impact of W.E.A. on graduates' outdoor leadership safety. Self-reports of rescues and evacuations conducted for each year precertification and postcertification were given, as well as detailed information on numbers and sizes of trips. These figures allowed comparisons of pre- and postcertification rescues and evacuations per participant day. Rescues were defined as the removal of an injured participant from a program site by another party. Evacuations were defined as removal by the victim's own party. Respondents also gave self-reports on the amount of influence W.E.A. had on accident rates in their leadership activities.

Finally, the "demonstration of a basic standard of outdoor leadership and experience" was operationalized for this study as the extent to which W.E.A.'s 16 specific curriculum elements were taken back to the graduate's subsequent outdoor leadership position and implemented there.

RESULTS

Forty-three percent of the W.E.A. graduates were females; 57 percent were males. The mean age was 27.4 years with a standard deviation of 6.8. Seventy-four percent of the graduates held at least a bachelor's degree, and 45 percent attributed at least some portion of their 1983 income to outdoor education-related employment. Fifty-three percent reported that they had been involved in formal outdoor leadership responsibilities prior to attending a W.E.A. course. Fifty-nine percent reported formal outdoor leadership responsibilities since completion of the course. Indication of formal leadership responsibilities <u>prior to</u> the W.E.A. course was used to distinguish outdoor leaders from other students for the remainder of the analyses reported here.

The mean score on course satisfaction was 5.58 (S.D. = 1.18) on a seven point scale ranging from "Couldn't have been more dissatisfied" to "Couldn't have been more satisfied." A group t-test showed no significant difference at the $p < .05$ level between satisfaction scores of outdoor leaders and those of other students. Ratings of the degree to which certification course objectives were met are summarized in table 1. Objectives relating to basic camping skills, environmental ethics, health and sanitation, rations planning, and expedition behavior were better than "largely met." Objectives involving natural history, weather prediction, adventure activities, first aid, and group processes were only "partially met," with somewhat greater variability in the responses. The ratings of outdoor leaders were uniformly higher than those of other students for all objectives, but only one difference reached significance at the $p < .05$ level.

Ratings of the fairness of students' performance evaluations had a mean of 4.27 (S.D. = 1.08) on a five-point scale ranging from "very unfair" to "very fair." Table 2 summarizes instructor effectiveness ratings on 10 evaluative dimensions. Most courses had two or three instructors, and respondents were asked to rate them separately to increase precision in their evaluations. Head instructors were rated better than "very good" overall with special strengths in knowledge of subject matter, appreciation of the environment, and technical skills. Second instructors were also rated "very good," but with an outstanding rating only in appreciation of the environment. Third instructors were rated somewhat lower, but again with a high rating in appreciation of the environment. The ratings given by the outdoor leaders were again uniformly higher across all 10 dimensions, but only two t-tests between outdoor leaders and other graduates reached significance at the $p < .05$ level ("Acted as a role model for you"; and "overall effectiveness").

Table 1.--Wilderness Education Association graduates' ratings of the degree to which course objectives were met

Objective	Mean degree to which objective was met[1] (S.D.)
Judgment	4.93 (.95)
Leadership	4.92 (.89)
Expedition Behavior	5.16 (.83)
Environmental Ethics	5.27 (.88)
Basic Camping Skills	5.46 (.70)
Rations Planning	5.21 (.76)
Equipment Selection and Use	4.89 (.96)
Clothing Selection and Use	5.12 (.87)
Health and Sanitation	5.26 (.76)
Travel Techniques	4.99[2] (.81)
Navigation	4.67 (.91)
Weather	4.02 (1.04)
First Aid and Emergency Procedures	4.55 (.94)
Natural and Cultural History	3.84 (1.12)
Special Travel/Adventure Activities	4.27 (1.27)
Group Processes and Communication Skills	4.56 (1.14)

[1]Objectives were rated on a six point scale with labels: 1 = Area not addressed; 2 = Not met at all; 3 = Slightly met; 4 = Partially met; 5 = Largely met; 6 = Completely met.
[2]t-test for differences between outdoor leaders and other graduates significant at $p \leq .05$.

Table 3 summarizes responses to the safety and impacts knowledge questions. For the five safety knowledge questions, percentages responding correctly ranged from 33 percent to 77 percent. Interestingly, the Cronbach's alpha reliability coefficient for this "scale" was .0036, with the highest inter-item correlation being .13. There was almost no relationship between correct responses to one item and correct responses to another. Removal of the lowest scoring item, which focused on an important but subtle legal liability issue, only increased the alpha to .19.

Percentages responding correctly to the conservation practices questions ranged from 19 percent to 91 percent. The Cronbach's alpha for this scale was .24 suggesting low internal consistency for knowledge of this subject matter as well. The item which most respondents answered incorrectly in this scale focused on staying on a muddy trail to minimize proliferation of trails in meadows. Fifty-five percent of the graduates responded that walking around the meadow in the forest was the preferable practice. While this response is not the W.E.A. standard minimum impact use practice and the item performed well in the pilot test, it may not validly measure the domain of minimum impact use knowledge standardized nationally. With removal of the item from the scale, the scale alpha increased to .36.

While caution must be used in interpreting these two collections of items as actual "scales" because of their lack of internal consistency, the mean number of items correct was 2.98 out of five for the safety items, and 3.54 out of five for the conservation practices items. Outdoor leaders scored slightly higher on both sets, but the differences were not significant at $p < .05$.

Only 38 W.E.A. graduates in the sample had led trips both before and after their W.E.A. course. These respondents were associated with 25 total evacuations prior to becoming certified (.0013 evacuations per participant day), and 23 after certification (.0004 per participant day). They reported 11 precertification rescues (.0005 per participant day) and five postcertification rescues (.0001 per participant day). While both of these pre-post changes are in the expected direction, paired t-tests performed on the differences were not significant ($p = .27$ for evacuations; $p = .37$ for rescues). In addition to these analyses, respondents rated the influence of W.E.A. certification on accidents in their current outdoor leadership activities. On a four-point scale ranging from "had a negative effect" (1) to "helped greatly" (4), the mean score for 120 respondents was $X = 3.08$ (S.D. = .822).

The final question addressed in this study was the degree to which W.E.A. graduates used the skills and knowledge gained through their certification course in their subsequent outdoor leadership activities. Table 4 summarizes the percentages of respondents involved in outdoor leadership after their course who reported implementing a curriculum area in their current activities either because of their W.E.A. experience or because of some other influence. W.E.A. appears most influential in the curriculum areas of expedition behavior, travel techniques in the wild outdoors, judgment, and rations

Table 2.--Wilderness Education Association graduate ratings of instructor effectiveness

Evaluative dimension	Mean for head instructor (n)[1]	Mean for second instructor (n)	Mean for third instructor (n)
Knowledge of subject matter	4.5 (251)	4.0 (203)	3.7 (79)
Ability to plan and administer materials and experiences	4.1 (251)	3.94 (201)	3.48 (80)
Interest in your goals and needs	3.78 (251)	3.79 (202)	3.77 (80)
Judgment and decision making skills	4.2 (251)	3.96 (201)	3.76 (80)
Appreciation of the environment	4.45 (251)	4.49 (202)	4.43 (80)
Acted as a role model for you	3.83 (248)[2]	3.80 (199)	3.57 (78)
Use of leadership techniques	4.02 (249)	3.91 (200)	3.63 (80)
Use of outdoor technical skills	4.41 (250)	4.07 (199)	3.92 (78)
Use of teaching skills	4.04 (250)	3.94 (200)	3.75 (78)
Overall effectiveness	4.15 (250)[2]	3.97 (201)	3.72 (78)

[1]Instructors were rated on five point scales labeled 1 = poor; 2 = fair; 3 = good; 4 = very good; 5 = excellent.
[2]t-tests for differences between outdoor leaders and other graduates significant at $p \leq .05$.

planning. Such subjects as basic camping skills, clothing and equipment selection, and environmental ethics are commonly practiced, but not as often because of the W.E.A. influence. Graduates are implementing a mean of 4.54 (S.D. = 4.94) W.E.A. curriculum areas out of 16 into their current leadership activities. Six percent are implementing all 16 areas due to the certification course, while 33.5 percent of the graduates are implementing none.

DISCUSSION

W.E.A. students are well-educated men and women, typically in their 20's. The mean age of W.E.A. graduates is eight years older than the mean age of National Outdoor Leadership School graduates (Easley 1985). About half the W.E.A. graduates are involved in formal outdoor leadership. The other half were apparently motivated to seek certification for other reasons which this study unfortunately did not address.

W.E.A. graduates appear quite satisfied with their courses. They felt most of the objectives of the course were at least partially met, with those pertaining to wilderness living and travel skills being most completely met. They reported being evaluated fairly for the most part, and they rated their instructors favorably on most dimensions. Instructors were especially commended for their appreciation of the environment.

Graduates who had been involved in outdoor leadership prior to their W.E.A. course were significantly older, and better educated. They consistently rated objectives to be more nearly met, were more satisfied, rated the instructors higher, and scored higher on knowledge scales. Despite this consistency, the differences were small, with only three of 29 t-tests reaching significance at the $p < .05$ level. We cannot conclude from these data that experienced outdoor leaders reacted to their courses differently from others.

Knowledge levels of W.E.A. graduates about outdoor safety and conservation practices were quite moderate. While a standard for comparison really does not exist, mean correct responses of 2.98 and 3.54 out of five questions seem low. The items developed to measure knowledge were thought to reflect the specific W.E.A. practices taught nationally, and they were based on curriculum content the authors judged to be highlighted by W.E.A. and somewhat unique to the W.E.A. curriculum. The items were subjected to a moderately rigorous review process.

Still, the low scores and low alphas suggest that these items have not tapped domains of knowledge retained by W.E.A. graduates. It is entirely possible that that knowledge does exist and this effort to measure it is not content valid. It is also possible that the W.E.A. curriculum is not well standardized across courses. In its attempt to reach more outdoor leaders across the country by decentralizing, W.E.A. may actually be

Table 3.--Wilderness Education Association graduates' scores on safety and impacts knowledge questions

Question	Percent answering correctly	n
Safety:		
Importance of sterile dishes	77.4	247
Reason for "release" forms	33.1	250
Responsibilities of "runners" in an evacuation	55.6	248
Acceptability of rapeling unbelayed	76.3	248
Minimum winter trip size	49.4	244
Conservation Practices:		
Acceptable wood for fires	91.4	235
Appropriate fire building techniques	76.7	232
The need to split up large hiking groups	72.0	247
Using soap in streams	93.8	253
How to walk in muddy trails	19.1	238

hindering its efforts to promote a basic standard of outdoor knowledge in these areas. Standards are difficult to monitor when programs are dispersed throughout the country. Outside training experiences of W.E.A. instructors may also influence the curriculum content they emphasize.

A third possible explanation for the low knowledge scores is that graduates are not exposed to the curriculum material in sufficient depth or for an adequately long time period. Both Rogers (1979) and Buell (1983) recommend apprenticeship periods in a certification sequence. While the 36-day W.E.A. approach is clearly a thorough immersion, perhaps it is not enough. Comparison of the W.E.A. approach to others is an important direction for future research.

There is some indication in these data that W.E.A. is more effectively standardizing conservation practices than safety practices. Mean knowledge levels for the conservation items were higher than for safety, and the internal consistency of this scale was somewhat higher. The environmental ethics course objectives were rated as more nearly met than objectives pertaining to first aid, emergency procedures, and survival. Additionally, instructors were rated higher on environmental awareness than any other evaluative rating. This curriculum area appears to be an effective part of the W.E.A. format and is perhaps the strongest argument for W.E.A.'s success.

Finally, however, the reports of postcourse curriculum implementation are noteworthy. The mean number of curriculum areas implemented into the graduates' programs is four out of 16, and one-third of the graduates who are employed in outdoor leadership are not implementing any of the curriculum areas due to the W.E.A. experience. Those areas in which W.E.A. appears to be having the greatest impact (expedition behavior, travel techniques, judgment, and rations planning) are central to the program but slightly different from the areas for which objectives are most highly met (basic camping skills, environmental ethics, health and sanitation, and rations planning). The certification course appears influential in some areas, but some curriculum areas were used in graduates' outdoor leadership activities prior to W.E.A.'s influence and may be standard practices already. Others are just not widely adopted by graduates. These may be inappropriate for certain settings in which outdoor leaders work. Alternatively, the training received may not be adequate to provide leaders with the confidence to teach the material themselves.

It would clearly be premature to claim that the Wilderness Education Association is the "Red Cross" of outdoor leadership. However, the program is growing. W.E.A.'s emphasis is not on indoctrinating graduates with absolute rules; rather, there is a cooperative effort in W.E.A. to explore new and better techniques for safe outdoor adventure. It might be possible to enhance the effectiveness of the certification course by discontinuing curriculum areas which are already well standardized in programs without W.E.A.'s influence. This would allow an emphasis on curriculum areas which are influential, but for which more attention would produce better standardization. This study has suggested that with a more narrow focus, W.E.A. might largely realize its goal of standardizing minimum impact use practices in organized outdoor programs. This clearly is a step in the direction anticipated by Wagar (1940) and Petzoldt (1974).

Further research is needed. The validation of a standardized outdoor leadership knowledge scale could be an important step in the professionalization of outdoor leadership. More objective behavioral measures of safety and conservation

Table 4.--Standardization of the certification curriculum in graduate leadership activities

W.E.A. curriculum area	Percent implementing due to W.E.A. (n = 155)	Percent implementing from other influences
Judgment	37.4	21.9
Leadership	27.7	31.0
Expedition Behavior	45.2	19.4
Environmental Ethics	29.7	44.5
Basic Camping Skills	21.3	49.7
Rations Planning	36.1	20.0
Equipment Selection and Use	25.8	41.9
Clothing Selection and Use	23.2	45.8
Health and Sanitation	30.3	37.4
Travel Techniques in the Wild Outdoors	39.3	29.0
Navigation	20.6	40.0
Weather	21.9	32.9
First Aid, Emergency Procedures, and Survival	23.8	38.7
Natural and Cultural History	20.6	37.4
Specialized Adventure Activities	20.0	36.8
Group Processes and Communication Skills	27.7	34.8

practices should be taken to confirm the self-report measures used in this study. Most importantly, perhaps, other outdoor leadership training programs and certification systems should be examined and compared with the W.E.A. approach to encourage a maximally effective process of professional development.

REFERENCES

Bradley, Jim. A human approach to reducing wildland impacts. In: Conference proceedings: Recreational impacts on wildlands; 1979 October 27; Seattle, WA. Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979: 222-226.

Buell, Larry. Outdoor leadership competency: a manual for self-assessment and staff evaluation. Greenfield, MA: Environmental Awareness Publications; 1983.

Cockrell, David. Opinions of Virginia's outdoor educators concerning standards, certification, and training. The Virginia Journal of Health, Physical Education and Recreation. 7(2): 17-18, 21; 1985.

Cockrell, David; LaFollette, Jude. A national standard for outdoor leadership certification. Parks and Recreation. 20(6): 40-43; 1985.

Cole, David N. Wilderness campsite impacts: effect of amount of use. Research Paper INT-284. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982.

Cole, David N. Reducing the impact of hikers on vegetation: an application of analytical research methods. In: Conference proceedings: Recreational impacts on wildlands; 1979 October 27; Seattle, WA. Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979: 71-78.

Cousineau, Claude. A delphi concensus on a set of principles for the development of a certification system for educators in outdoor adventure programs. Greeley, CO: University of Northern Colorado; 1977. Ph.D. dissertation.

Easley, A. T. The personality traits of wilderness leadership instructors at NOLS: the relationship to perceived instructor effectiveness and student self concept. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1985. Ph.D. dissertation.

Fazio, James R. Information and education techniques to improve minimum impact use knowledge in wilderness areas. In: Conference proceedings: Recreational impacts on wildlands; 1979 October 27; Seattle, WA. Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979: 227-234.

Hendee, John C.; Roggenbuck, Joseph W. Wilderness-related education as a factor increasing demand for wilderness. Paper presented at the International Forest Congress Convention; Quebec City; 1984.

Ittner, R.; Potter, D. R.; Agee, J. K.; Anschell, S. Conference proceedings: Recreational impacts on wildlands. Publication R-6-001-1979. Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; 1979.

Ewart, Alan; Johnson, W. Outdoor adventure leadership: a study of current issues facing the profession. Proceedings: Intermountain leisure symposium; Provo, UT: Brigham Young University; 1983: 53-56.

LaPage, Wilbour F. Financing the wilderness with user taxes or "when will the dinosaur die?" Paper presented at the Conference on Fees for Outdoor Recreation on Lands Open to the Public, Durham, NH; 1984.

McAvoy, Leo H.; Dustin, Dan L. The right to risk in wilderness. Journal of Forestry. 79: 150-152; 1983.

Miller, Joseph W.; Miller, Margaret M. Propagation of plant material for subalpine revegetation. In: Conference proceedings: Recreational impacts on wildlands; 1979 October 27; Seattle, WA. Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; 1979: 304-310.

Petzoldt, Paul. The wilderness handbook. New York: Norton; 1974.

Petzoldt, Paul. The wilderness handbook. 2nd edition. New York: Norton; 1984.

Rogers, Robert J. Leading to share: sharing to lead. Sudbury, Ontario: Council of Outdoor Educators of Ontario; 1979.

Senosk, Elaine M. An examination of outdoor pursuit leadership certification and licensing within the U.S. in 1976. Eugene, OR: University of Oregon; 1977. M.S. thesis.

Shelby, B.; Danley, M. S.; Gibbs, K. C.; Petterson, M. E. Preferences of backpackers and river runners for allocation techniques. Journal of Forestry. 80: 416-419; 1982.

Stankey, George H.; Baden, J. Rationing wilderness use: methods, problems, and guidelines. Research Paper INT-192. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977.

Young, Anderson B. Leave wilderness alone. Camping Magazine. 57(6): 14-15, 35; 1985.

Wagar, J. V. K. Certified outdoorsmen. American Forests. 46: 490-492, 524-525; 1940.

Section 7. Wilderness Visitor Attitudes and Behavior Research

WILDERNESS ATTITUDES AND BEHAVIOR RESEARCH--FROM HERE TO WHERE?

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In his seminal work Experience and Prediction, science philosopher Hans Reichenbach (1938) distinguishes between two contexts within which science operates: discovery and justification. These two faces of science each demand a different form of activity on the part of a scientist. Good science, according to Reichenbach, requires both discovery and justification--the former being a necessary prelude to the latter.

The context of discovery has to do with the process of happening upon new knowledge, new theories, and new hypotheses. Here we find the creative, unbridled, and nonlogical side of science (Popper 1959). There is no kind of system or methodology; anything goes. The emphasis is upon conception. There is a good deal of pondering and messing about. Questions are raised, existing tenets are doubted, old problems are recast into novel configurations, nontraditional routes of inquiry are explored, new ways of structuring knowledge are imagined, and new propositional relationships are conceived. Knowledge, theories, and hypotheses are schemes to be created--not schemes to follow. The discovery context offers a time for great freedom, high exploratory excitement, and minimal accountability. It is a context for imagining what is and what can be, without really knowing (or perhaps even caring) whether it is right or wrong.

The context of justification has to do with the process of validating new knowledge, new theories, and new hypotheses. Here we find the controlled, disciplined, analytical, and logical part of science (Cohen and Nagel 1934). It is that which most of us have come to appreciate as "the scientific method." It insists that a clear statement of conjecture be made, and that activities be organized around the need to substantiate or falsify the conjecture. The emphasis is upon correction. The aim is to build beliefs decided upon by evidence, not by appeal to intuitive processes. There are definite sets of procedural rules for building evidence; those not adhering to the rules are zealously sanctioned by the scientific community. The justification context demands great rigor, order, logical consistency, and tedious attention to detail. It is a context for establishing whether the products of our imagination are right or wrong.

A DISCOVERY CONTEXT

Although good science demands both discovery and justification, it seems that research on wilderness attitudes and behavior has been emerging almost entirely from a discovery context. The state-of-knowledge review produced for this conference by Stankey and Schreyer identifies scores of studies dedicated to the formation of information and conjecture, but only a handful dedicated to the validation of information and conjecture. Most studies involve tabular analyses of opinion polls. Studies involving working hypotheses that formalize conjecture and force it to test are the exception rather than the rule.

It is not that our paths of inquiry have been unfruitful. The state-of-knowledge review identifies many accomplishments that shake our world views and that fuel speculation about the character of human response to the wilderness environment and wilderness policy. Discovery-oriented research has, for example, confronted us with the possibility that our personal attitudes toward wilderness are not universally shared. It has enlivened our appreciation for the complexity of the choice process and has generated a wealth of material on why certain settings might be preferred over others. It has created scores of case studies on visitor responses to wilderness management practices--relating to such diverse themes as fire management, trail and bridge construction, safety, interpretive services, campsite facilities, mineral extraction, and behavioral regulations. It has provided voluminous information on how case groups of visitors feel about encountering others and on what the psychological and behavioral consequences of these findings might be. And it has precipitated a good deal of speculation on the character of linkages among such processes as visitor motivation, perception, behavior, and satisfaction.

Yet with all these accomplishments, the flow of research has not been organized around the systematic testing of propositions about the character of wilderness attitudes and behavior. Emphasis has not been placed upon the organization and justification of conjecture. In the Kuhnian (1962) sense, we are in a period of

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prescience--a period marked by diverse and disorganized activity. We are still trying to come to grips with what the character of wilderness attitudes and behavior research should be.

SOCIAL PSYCHOLOGY ADVANCES

This is somewhat befuddling in light of the more than four decades of progressive expansion of attitudes and behavior research in social psychology (Schuman and Johnson 1976). We in wilderness research organize our activities only rarely around the emerging theoretical perspectives of that strongly justification-oriented discipline. A notable exception, of course, is our frequent employment of the theory of reasoned action (Ajzen and Fishbein 1977). We need to recognize, however, that this theory is not without controversy (for example, Sarver 1983) and represents but one of many emerging paradigms within the field of attitude and behavior research (Cushman and McPhee 1980). Strongly underutilized are revelations from such alternate perspectives as attribution theory (Kelly 1955), behavioral process theory (Jacoby 1975), contingency rules theory (Smith 1984), information integration theory (Anderson 1982), linear force aggregation theory (Woelfel 1980), memory theory (Loken 1984), reciprocal determinism theory (Bandura 1978), self-perception theory (Bem 1972), script processing theory (Abelson 1976), and value theory (Rokeach 1968).

We have tended to dwell almost exclusively on the traditional bounded rationality models (Bettman 1979) without examining the potential of the emerging experiential models (Holbrook and Hirschman 1982). We have not fully appreciated the distinction between behavioristic and cognitive/developmental approaches to the study of attitudes and behavior (Burgoon and others 1981). And we have not borrowed freely from the technologies made available by stochastic, mathematical, and cybernetic models of behavior and attitude change (for example, Hewes 1980). We have such insights to draw upon to move into a more theory-driven, justification-oriented style of research. Until we do, our research will be incapable of converging upon fundamental laws governing wilderness attitudes and behavior.

EXPANDING OUR APPRECIATION

In the meantime, we can continue to be nourished by the freshness and excitement of a largely discovery-oriented tradition. As a whole, the eight papers that follow superbly represent this tradition in wilderness research.

Dorothy Anderson and Michael Manfredo tabulate visitor preferences for a variety of management practices and emerge with the speculation that support for heavy-handed intervention increases with apparent overuse. Richard Shew and associates analyze managers' feelings about recreational horse use and sense that many of the problems associated with it might be alleviated through visitor education programs. Alan Ewert takes on the proverbial question of why people climb mountains and discovers that the answer may have at least five components. Rachel Robertson takes on the important methodological question of how best to measure wilderness behavior and discovers unexpected congruency between actual behavior and visitor recall reporting of that behavior. James Absher and Leo McAvoy prompt us to consider unique researchable issues associated with the management of defacto wilderness; in so doing, they discover unanticipated support for wilderness values on the part of a group of commercial users. Lan-Hung Nora Chiang offers a much-needed international perspective, yielding data on desired experiences and management preferences of visitors to a national park in Taiwan.

The papers by Daniel Williams and Michael Huffman and by Alan Graefe and associates emerge more from a justification context. Their conjecture was that variability in environmental perception and preference can be explained, in part, by variability in level of recreation specialization (Bryan 1979). The conjecture was supported--in terms of trail preferences (Williams and Huffman) and crowding perceptions (Graefe and others). The importance of these papers lies in their use of theory-based deduction to account for previously unexplained variance in specific attitudinal measures.

WHERE FROM HERE?

Having benefited from past research and this new collection of studies, we need to pause to wonder where we should go from here. With an eye toward improving the stature of our science, it seems clear that Hans Reichenbach would insist that we channel currents of inquiry into a theory-driven, justification-oriented context. Yet in so doing, we must not abandon our strong tradition in discovery-oriented research, which generates its own kinds of benefits. What is needed is a balance of discovery and justification; too much of either introduces an extreme that is counterproductive to the growth of a discipline (Silverman 1977).

Regardless of where our own personal aptitudes take us--into discovery or into justification--each of us must strive to make our individual efforts more important. Science philosopher Rolfe Leary (1985) has suggested a two-dimensional evaluative scheme for determining the relative importance of a particular research effort. First, one should assess the level of difficulty of the question being asked by the research. The least difficult questions involve description ("what is?"), more difficult questions involve prediction ("what if?"), and the most difficult questions involve explanation (why?). Second, one should assess the level of generality of the answer given by the research. The least generalizable answers limit inference to one case, more generalizable answers limit inference to certain sample populations, and the most generalizable answers have no inferential limits. Professor Leary informs us that the more

important research efforts are those that ask the most difficult questions and supply the most generalizable answers. Perhaps one of the greatest needs in wilderness research is to incorporate such importance criteria as design factors in future studies.

Wilderness attitudes and behavior research is yet in a primordial state, particularly when contrasted with the theoretical richness of its parent discipline--social psychology. As each of us carves our personal research initiatives, we should be sensitive to the needs for theory, for justification, and for importance. Our field of inquiry will then blossom into a mature science, complete with systems of laws highly explanatory of the complex character of transactions that occur between humans and the wilderness environment.

REFERENCES

Abelson, R. P. Script processing in attitude formation and decision-making. In: Carroll, J. S.; Payne, J. W., eds. Cognition and social behavior. New York: Academic Press; 1976: 33-45.

Ajzen, I.; Fishbein, M. Attitude-behavior relations: a theoretical analysis and review of empirical research. Psychological Bulletin. 84: 888-991; 1977.

Anderson, N. H. Foundations of information integration theory. New York: Academic Press; 1982. 312 p.

Bandura, A. The self system in reciprocal determinism. American Psychologist. 33: 344-358; 1978.

Bem, D. J. Self-perception theory. In: Berkowitz, L., ed. Advances in experimental social psychology, Vol. 6. New York: Academic Press; 1972: 43-72.

Bettman, J. R. An information processing theory of consumer choice. Reading, MA: Addison-Wesley; 1979. 482 p.

Bryan, H. Conflict in the great outdoors. Tuscaloosa, AL: University of Alabama Social Studies No. 4; 1979. 99 p.

Burgoon, J. K.; Burgoon, M.; Miller, G. R.; Sunnafrank, M. Learning-theory approaches to persuasion. Human Communication Research. 7(2): 161-179; 1981.

Cohen, M.; Nagel, E. An introduction to logic and the scientific method. New York: Harcourt; 1934. 356 p.

Cushman, D. P.; McPhee, R. D. Message-attitude-behavior relationship: theory, methodology, and application. New York: Academic Press; 1980. 339 p.

Hewes, D. E. An axiomatized, stochastic model of the behavioral effects of message campaigns. In: Cushman, D. P.; McPhee, R. D., eds. Message-attitude-behavior relationship: theory, methodology and application. New York: Academic Press; 1980: 43-89.

Holbrook, M. B.; Hirschman, E. C. The experiential aspects of consumption: consumer fantasies and fun. Journal of Consumer Research. 9: 132-140; 1982.

Jacoby, J. Perspectives on a consumer information processing research program. Communications Research. 2: 203-215; 1975.

Kelly, G. A. The psychology of personal constructs. New York: Norton; 1955. 431 p.

Kuhn, T. S. The structure of scientific revolution. Chicago: The University of Chicago Press; 1962. 292 p.

Leary, R. A. A framework for assessing and rewarding a scientist's research productivity. Scientometrics. 7(1): 29-38; 1985.

Loken, B. Attitude processing strategies. Journal of Experimental Social Psychology. 20: 272-296; 1984.

Popper, K. The logic of scientific discovery. New York: Harper and Row; 1959. 252 p.

Reichenbach, H. Experience and prediction. Chicago: University of Chicago Press; 1938. 432 p.

Rokeach, M. A theory and organization of change within value-attitude systems. Journal of Social Issues. 24: 13-34; 1968.

Sarver, V. T. Ajzen and Fishbein's "Theory of Reasoned Action": a critical assessment. Journal for the Theory of Social Behavior. 13(2): 155-163; 1983.

Schuman, H.; Johnson, M. P. Attitudes and behavior. Annual Review of Sociology. 2: 162-202; 1976.

Silverman, I. Why social psychology fails. Canadian Psychological Review. 18(4): 353-358; 1977.

Smith, M. S. Contingency rules theory, context and compliance theory. Human Communication Research. 10(4): 489-511; 1984.

Woelfel, J. Foundations of cognitive theory: a multidimensional model of the message-attitude-behavior relationship. In: Cushman, D. P.; McPhee, R. D., eds. Message-attitude-behavior relationship: theory, methodology and application. New York: Academic Press; 1980: 89-116.

AN EXAMINATION OF THE EFFECTS OF WILDERNESS DESIGNATION ON HIKER ATTITUDES

Anthony J. Fedler and Fred R. Kuss

ABSTRACT: Effects on hikers of changing the management designation of an area from backcountry to wilderness were examined. Hikers generally felt that impacts on the physical environment would increase while social impacts would decrease under wilderness management conditions. Attitudes and intentions toward hiking in the area as wilderness were significantly lower than for the area as backcountry. Implications of the research are discussed.

INTRODUCTION

The purpose of this paper is to determine if hiker attitudes and intentions towards hiking in a backcountry area change when the area is formally designated as a wilderness area. This question is predicated by the fact that official wilderness designation usually requires changing traditional recreational use patterns within the designated area to assure that the values of naturalness and solitude are preserved (Hendee and others 1978). Motorized vehicle use is prohibited and wilderness visitors such as hikers and campers can expect some type of use regulation either by direct use rationing or mandatory use permits in a majority of the nation's wilderness areas.

According to a study of wilderness area managers by Washburn and Cole (1983), use rationing was being used as a wilderness management tool in about fifteen percent of the nation's wilderness areas in 1980. Managers of another five percent of the wilderness areas indicated that they were planning to institute use rationing within the next few years. Further, mandatory use permits for entering an area, overnight camping or for specific groups of users were required in forty-two percent of the wilderness areas where direct use rationing was not used.

The extent to which 1980 wilderness use regulations reported by Washburn and Cole (1983) differed from pre-wilderness designation regulations is unknown. However, Anderson and Brown (1984) suggest that changes in the management direction of an area (i.e., from backcountry to wilderness) could result in the displacement of some traditional visitors. For example, some users of an area could view wilderness designation very positively in terms of protecting the resource and enhancing opportunities for solitude. Other hikers may view designation negatively because controls on visitor numbers and travel patterns may reduce the social contact levels and freedom outcomes important to them.

This line of reasoning is countered to some degree by the results of a study by Schomaker and Glassford (1982). Their study indicated that wilderness users are very similar to backcountry users in terms of their attitudes toward facility development, motorized travel, and encounters with others. Thus, these results suggest that changes in an area's designation from backcountry to wilderness should result in little, if any, effect on area users.

Outcomes desired by users can be viewed as their beliefs about the area's ability to provide the types of experiences they are seeking (Triandis 1970; Fishbein 1963; Fishbein and Ajzen 1975). These beliefs are based on past experience, literature, and other sources of information. According to Triandis (1970) and Fishbein and Ajzen (1975) new information, such as changing the management status of backcountry to wilderness, may change the beliefs an individual holds about the area and the resulting attitude he or she holds concerning using the area. It follows, then, that a significant change in attitude could result in a change in intentions to use the area in the future. Thus, a comparison of attitudes and behavioral intentions concerning hiking in a particular area as backcountry and as wilderness should reveal the effect changes in designation would have on hiker behavior. Further, examining differences in backcountry and wilderness beliefs should provide some insight into which perceptions of the area changed (Ajzen and Fishbein 1980). The following null hypotheses were generated to test for the differences outlined above:

H_1: There are no differences in individual social and physical environment beliefs about an area managed as backcountry or wilderness.

H_2: There are no differences in individual attitudes toward hiking in an area managed as backcountry or wilderness.

H_3: There are no differences in individual intentions to hike in an area managed as backcountry or wilderness in the future.

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METHODS

The Pemigewasset area of the White Mountain National Forest was the setting used to test the study's hypotheses. On June 19, 1984, the New Hampshire Bill (H.R. 3921) was signed into law by President Reagan. This act established the 45,000 acre Pemigewasset Wilderness as part of the National Wilderness Preservation System. Management of the area during the summer of 1984 when the study was conducted was essentially the same as in past years when the Forest Service managed the area as backcountry.

Hikers in the Pemigewasset area of the White Mountain National Forest were surveyed during July and August, 1984, to obtain information on their personal characteristics, beliefs, attitudes, and other aspects of their hiking experience. The objective of the sampling procedure was to contact a cross-section of hikers on lightly and heavily used trails throughout the area in an effort to include as many individuals as possible. No attempt was made to randomize interview days or trail sections within the study area. Rather, lightly and heavily used trails were systematically traveled on weekdays and weekend days by study personnel who asked all hikers and campers they encountered to complete a self-administered questionnaire. Over the course of the study, 426 hikers completed the two page questionnaire. Twenty additional hikers refused to complete the survey form.

Beliefs about the Pemigewasset area as backcountry were measured by asking visitors to rate how common five physical environment and seven social environment conditions were during their current trip to the area. These twelve salient belief statements were generated from a list of 25 statements which were pretested on 52 hikers using the Pemigewasset area prior to the initiation of the main survey. The 25 belief statements were adapted from other studies such as Anderson and Brown (1984), and Cockrell (1981). Salient beliefs were defined as all beliefs rated as at least slightly common by 30 percent or more of the respondents in the pretest. Responses to the belief statements were measured on a 7-point (0-not at all to 6-very common) scale.

Additionally, hikers rated the same twelve beliefs for the future when the Pemigewasset area would be managed as a designated wilderness area. Responses were made upon the same 7-point (not at all common to very common) response format mentioned above. The question measuring future wilderness beliefs was prefaced by the following statement:

> As now a fully designated Wilderness, this area will be managed differently than in the past. Changes such as restricting overnight use to fewer people, permit requirements, and phasing out of some of the existing campsites may occur. How common do you feel each of the following will be in the future?

Evaluations of the twelve salient beliefs were measured by asking respondents how encountering each physical and social environment condition would add to or detract from their experience while hiking in the area. The 7-point response format ranged from strongly detracts (-3) to strongly adds (+3). The pretest instrument mentioned above included belief evaluations for both backcountry and wilderness. Analysis of the responses to the backcountry and wilderness belief evaluations resulted in no significant differences. Thus, only one belief evaluation scale for the twelve conditions was included on the main survey instrument. This occurrence also facilitated shortening of the pretest survey instrument which took respondents about 30 minutes to complete.

Development of the above framework for examining the impact of various social and environmental conditions on hiking experiences is based upon the work by Ajzen and Fishbein (1980) and further tested for the study of outdoor recreation by Fedler (1981), Anderson and Brown (1984), and Young and Kent (1985). The model, adapted for this study and outlined below, shows the relationships between beliefs, evaluations of the beliefs, and an individual's attitude toward the area as backcountry and wilderness:

$$A_i = \sum_{i}^{n} b_i e_i$$

where: A_i is the attitude toward the area,
b_i is the belief about observing the condition in the area (commonness), and
e_i is an evaluation of the favorableness or unfavorableness (impact) of observing the condition on the experience.

Thus, the summation of individual belief X evaluation products should reflect the hiker's attitude or feeling about the area.

Attitudes toward hiking in the area under backcountry management and in the future under wilderness management conditions were also probed. Unlike attitudes toward the area, attitudes toward hiking in the Pemigewasset were measured by using a six-item semantic differential scale to quantify the affective feeling (positive-negative) toward hiking in the area as backcountry and wilderness. This procedure follows that outlined by Fishbein and Ajzen (1975) and Ajzen and Fishbein (1980) for determining attitude strength when understanding the underlying beliefs is not of concern. Each semantic differential word pair was rated on a scale ranging from (+3) to (-3). The word pairs used were pleasant-unpleasant, desirable-undesirable, valuable-worthless, satisfying-frustrating, nice-awful, and acceptable-unacceptable. Development and selection of these word pairs was based upon previous work by Osgood and others (1957) and Fedler (1981). Word pair scores were summed and used as an indicator of an individual's overall attitude towards hiking in the Pemigewasset area as backcountry and wilderness. The scale for attitudes toward hiking in the wilderness was prefaced by a statement paralleling that used above for belief measurement.

Intentions to hike in the area in the future as backcountry and wilderness were also measured.

A 7-point behavioral differential scale (Triandis 1964) was used in both cases to measure the probability that an individual would return to hike the area in the future. Responses ranged from not at all likely (0) to very likely (6).

RESULTS

Before the hypotheses could be tested, it was necessary to determine the extent to which users of the Pemigewasset area were aware that the area had received official designation as wilderness earlier in the year. A question that was included on the questionnaire asked if the respondent was aware of the recent designation. Only 35 or eight percent of the 426 individuals contacted were aware of the designation and were subsequently deleted from the analysis to avoid any confounding effects. Informal discussions with respondents after the survey was completed reinforced the general lack of knowledge of the designation. As a result, we concluded that the designation prior to our survey had a negligible effect on responses to belief and attitudinal questions being examined in this study.

Beliefs and Attitudes About the Area

In order to test the first hypothesis, beliefs about the physical and social environments were measured for backcountry and wilderness management designations. Beliefs about the physical environment are shown in table 1. In general, the five physical environment impacts listed in the table were rated as slightly common for both backcountry and wilderness management conditions. Hikers did rate seeing litter along trails, in campsites, and around shelters as being more common under wilderness management conditions than for backcountry. Camping in heavily used campsites was perceived to be less common under future wilderness management conditions. Seeing worn-out campsites would essentially remain the same.

Impacts on the social environment were rated slightly more common than physical impacts for both backcountry and wilderness management designations (table 1). Four of the seven social impacts were rated differently under backcountry and wilderness management conditions. Camping within hearing distance of other campsites, camping at sites easily seen from other campsites, and seeing small groups on the trails all were thought to be less common under wilderness management. Contact with noisy groups would increase under wilderness management. Seeing large groups on the trails, too many other hikers, and hikers passing by the campsite were essentially rated the same under the two management conditions.

Hikers were asked to rate how encountering each of the physical and social environment conditions would add to or detract from hiking in the Pemigewasset area. Responses to the twelve items are shown in table 2. Encountering any of the five physical conditions would strongly or moderately detract from the experiences of a large majority of area hikers. On the other hand, encountering any of the seven social conditions elicited mixed responses. For example, coming into contact with noisy people, and camping within seeing or hearing distance of other campers would detract from the experience of most visitors. The remaining social conditions, except seeing small groups, would slightly detract from the experience. Seeing small groups would have no effect on experience for nearly half of the respondents. The remaining half were evenly split between adding and detracting from the experience.

Table 1.--Differences in beliefs about the physical and social environments: current backcountry versus wilderness management conditions

	Backcountry Mean Rating	Wilderness Mean Rating	t Value	Prob.
Physical Environment Belief				
See litter along the trails	0.81	1.50	-9.35	<.001
Find litter in campsite areas	1.30	1.74	-5.12	<.001
Find litter around shelters	1.14	1.66	-5.99	<.001
See worn-out campsites	1.57	1.77	-1.91	.057
Camp in heavily used campsites	2.24	1.86	2.94	.003
Social Environment Belief				
Camp within hearing distance of other's campsites	2.74	1.99	5.72	<.001
Camp at sites easily seen from other's campsites	2.76	1.94	5.72	<.001
Come into contact with noisy people	1.29	1.93	-6.47	<.001
See small groups on trails	3.52	2.89	5.63	<.001
See large groups on trails	2.20	2.22	-0.19	.850
See too many other hikers	1.77	1.97	-1.87	.063
See hikers pass by your campsite	2.08	2.23	-1.17	.243

Response format ranged from (0)-not at all common to (6)-very common.

Table 2.--Evaluations of how encountering selected physical and social conditions would affect the hiking experience

	Mean Rating
Physical Environment Belief	
See litter along the trails	-1.83
Find litter in campsite areas	-1.76
Find litter around shelters	-1.75
See worn-out campsites	-1.31
Camp in heavily used campsites	-1.29
Social Environment Belief	
Camp within hearing distance of other's campsites	-1.34
Camp at sites easily seen from other's campsites	-1.23
Come into contact with noisy people	-1.68
See small groups on trails	0.18
See large groups on trails	-0.59
See too many other hikers	-0.77
See hikers pass by your campsite	-0.56

Response format ranged from (-3)-strongly detracts to (+3)-strongly adds

Belief and evaluation scores were multiplied for each individual to determine the impact of each of the physical and social conditions on hiker experiences (table 3). These scores were then summed to produce an overall score representing an individual's attitude toward the Pemigewasset area. Impacts of the five physical conditions on hiker experiences were negative for both backcountry and wilderness management situations. The impacts of three of the physical conditions pertaining to litter were significantly more negative under wilderness management conditions than under backcountry management. Social condition impacts, except for seeing small groups, were likewise rated negatively by respondents. Camping within sight or hearing distance of other campsites, seeing large groups, and seeing hikers pass by the campsite were all rated less negatively under wilderness management conditions. Coming into contact with noisy people was rated more negatively for wilderness.

Based on the results presented in tables 1 and 2, Hypothesis 1 was rejected. Four of the five physical environment beliefs and four of the seven social environment beliefs were significantly different. While the summated belief x evaluation scores, representing attitude toward the Pemigewasset, were not significantly different, the structure of the physical and social conditions comprising each attitude was considerably different.

Attitudes and Intentions Toward Hiking

Hypothesis 2 examined hiker attitudes toward hiking in the Pemigewasset area under backcountry and wilderness management conditions. Here the focus is on the behavior of hiking in the area rather than on the characteristics of the area (object) itself. Attitudes toward hiking under each management situation were measured on a six-item semantic differential scale. Word-pairs used were pleasant-unpleasant, desirable-undesirable, valuable-worthless, satisfying-frustrating, nice-awful, and acceptable-unacceptable. Responses were made on a seven-point format (e.g., very pleasant (+3) to very

Table 3.--Differences in belief x evaluation scores for the physical and social environments: current backcountry versus future wilderness management conditions

	Backcountry Mean B x E Rating	Wilderness Mean B x E Rating	t Value	Prob.
Physical Environment				
See litter along the trails	-1.46	-2.88	-8.08	<.001
Find litter in campsite areas	-2.32	-3.03	-3.88	<.001
Find litter around shelters	-1.99	-2.93	-4.98	<.001
See worn-out campsites	-2.46	-2.39	0.33	.738
Camp in heavily used campsites	-2.70	-2.51	1.40	.480
Social Environment				
Camp within hearing distance of other's campsites	-3.51	-2.28	4.40	<.001
Camp at sites easily seen from other's campsites	-3.19	-1.78	5.26	<.001
Come into contact with noisy people	-2.32	-3.36	-4.63	<.001
See small groups on trails	1.31	1.09	-1.56	.120
See large groups on trails	-1.39	-1.02	1.93	.050
See too many other hikers	-1.37	-1.22	0.85	.395
See hikers pass by your campsite	-1.17	-0.68	2.43	.016
Summated Attitude Toward Area	-29.43	-27.58	1.03	.195

Response format ranged from -18 to +18

unpleasant (-3). An Alpha reliability coefficient (Cronbach 1959) was calculated on each of the six-item scales. The alphas of .93 for the backcountry attitude scale and .97 for the wilderness attitude scale indicate very high internal consistency for both scales.

Mean attitude scores are shown in table 4. Attitudes toward hiking in the area as backcountry were very positive with a mean of 2.23. Attitudes toward hiking in the Pemigewasset area under wilderness management conditions were significantly lower with a mean of 0.89. This represents a substantial downward shift in attitude between backcountry and wilderness management conditions.

An investigation of Hypothesis 3 resulted in a similar downward shift in intentions to hike in the area as backcountry and as opposed to wilderness. As seen from table 4, intention ratings declined by nearly a full point on the seven-point response format indicating that many hikers thought they would be less likely to hike in the area under wilderness management conditions than under backcountry management conditions.

The final analytical step was to correlate the attitude toward the area and attitude toward hiking in the area measures and the attitude toward hiking intention measures to examine the strength of the relationships for backcountry and for wilderness. The correlation between the summated attitude towards the area score and attitude towards hiking scale score was significant for backcountry ($r=.67$, $p<.001$) and wilderness ($r=.71$, $p<.001$). The attitude toward hiking scale scores were significantly correlated with intention to hike in the Pemigewasset under backcountry ($r=.72$, $p<.001$) and wilderness ($r=.70$, $p<.001$) management conditions. Thus, attitudes about the area as backcountry and wilderness were strongly related to attitudes toward hiking in the area. Further, attitudes toward hiking in the area were highly predictive of future intentions to hike in the area for both backcountry and wilderness management conditions.

DISCUSSION AND CONCLUSIONS

Results led to the rejection of the three null hypotheses examined in this study. There were consistent changes in the beliefs about the area, attitudes towards hiking in the area, and future hiking intentions of respondents when management changed from backcountry to wilderness. The occurrence of four of the five physical environment beliefs were significantly different between backcountry and wilderness management conditions. Litter was perceived to be more common when the area came under wilderness management but camping in heavily used campsites would be less common. Four of the seven social environment beliefs were also rated differently by respondents. Camping within sight and hearing distance of others and seeing small groups on trails were perceived as being less common under wilderness management conditions than under backcountry management. However, coming into contact with noisy hikers would increase under wilderness conditions. Attitudes about hiking in the Pemigewasset area changed significantly when future wilderness management conditions were considered. This change was paralleled by a similar change in intentions to hike in the area when wilderness management conditions prevailed.

Individual attitudes toward the Pemigewasset area, represented by the five physical and seven social beliefs about the Pemigewasset area, were strongly related to attitudes about hiking in the area under both backcountry and wilderness management conditions. This finding is somewhat unexpected as Fishbein and Ajzen (1975) suggest that these measures may not necessarily be highly correlated since attitude towards the area is related to a variety of characteristics of the area whereas attitude towards hiking reflects an affective state about performing a behavior in the area. Differences in attitudes toward hiking in the area can clearly be linked to changes in beliefs about the area under backcountry versus wilderness management conditions. Likewise, a change in management designation resulted in significantly lower intentions to hike in the area in the future. The strength of the correlations between attitude towards the area, attitude towards hiking in the area and hiking intentions underscores the importance of attitudes in determining behavior.

While there appears to be general support for the major contention of this paper that changing the management designation of an area can result in a significant impact on the users of that area, a number of points need to be considered to put these results into proper perspective. First, the scenario we posed for the future management of the Pemigewasset area as wilderness may not be accurate. The scenario we chose reflects our best estimate of what would happen after consultation with White Mountain National Forest managers and what has happened in other wilderness areas. Changing the

Table 4.--Attitudes and intentions toward hiking in the study area: current backcountry versus wilderness management conditions

Variable	Backcountry Mean Rating	Wilderness Mean Rating	t Value	Prob.
Attitude towards hiking	2.23	0.89	10.04	<.001
Intention towards hiking	4.68	3.71	12.41	<.001

Attitude scale response format ranged from -3 to +3
Intention response format ranged from (0)- not at all likely to (6)-very likely

scenario might yield different perceptions and attitudes on the part of survey respondents. Additionally, the scenario we developed had a somewhat negative connotation. An explanation of the benefits associated with overnight camping restrictions, permit requirements, and elimination of some designated campsites may have produced somewhat different results.

Second, correlations between beliefs and attitudes and between attitudes and intentions were moderately high but could still be stronger. There may be additional beliefs that are relevant to the formulation of an individual's attitude about hiking in the area. Further, the same set of beliefs may not be appropriate for both backcountry and wilderness. Identifying the relevant beliefs about hiking in different settings (both physical and managerial) needs to be studied further.

Third, our study focused on intentions as the behavioral measure; and in so doing no definitive conclusion can be drawn relative to the future actual behavior of the respondents. Fishbein and Ajzen (1975) show that intentions and behavior are related if measured in close proximity to each other. However, as time passes and more information such as management information about the Pemigewasset Wilderness area, other hiker reports about hiking conditions in the wilderness, and newspaper articles about the area may change hiker beliefs about the area. These belief changes may lead to a new attitude about hiking in the area with corresponding changes in intentions and behavior.

Fourth, lack of randomization of trails sections covered and interview days does not permit us to extrapolate the results of our study beyond the individuals in our sample. This does not pose any major problems since we were interested in probing the relationships between beliefs, attitudes, intentions and the two management conditions.

Finally, future studies need to be designed to more fully address the impacts of wilderness designation on users of the wilderness. Panel studies identifying backcountry users prior to designation and following them through a few years after wilderness designation are needed to adequately measure attitudinal and actual behavioral changes associated with changing management conditions.

REFERENCES

Ajzen, I.; Fishbein, M. Understanding attitudes and predicting behavior. Englewood Cliffs, NJ: Prentice-Hall; 1980.

Anderson, D. H.; Brown, P. J. The displacement process in recreation. Journal of Leisure Research. 18: 61-73; 1984.

Cockrell, D. E. Motivation, satisfaction and social influence in wild river recreation. Moscow: University of Idaho; 1981. 143 p. Ph.D. dissertation.

Cronbach, L. J. Coefficient alpha and the internal structure of tests. Psychometrika. 16: 297-334; 1951.

Fedler, A. J. Attitudes, subjective norms and behavioral intentions as inputs for understanding recreation behavior. College Station: Texas A & M University; 1981. 133 p. Ph.D dissertation.

Fishbein, M. An investigation of the relationships between beliefs about an object and the attitude toward the object. Human Relations. 16: 233-240; 1963.

Fishbeing, M. & Ajzen, I. Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley; 1975.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Miscellaneous Publication No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978.

Kuss, F. R.; Fedler, A. J. A survey of trail use and users of the Pemigewasset Wilderness area. College Park, MD: University of Maryland Department of Recreation; 1985.

Osgood, C. E.; Suci, G.; Tannebaum, P. The measurement of meaning. Urbana: University of Illinois Press; 1957.

Schomaker, J. H.; Glassford, T. R. Backcountry as an alternative to wilderness? Journal of Forestry. 82: 358-364; 1982.

Triandis, H.C. Exploratory factor analyses of the behavioral component of social attitudes. Journal of Abnormal and Social Psychology. 68: 420-430; 1970.

VISITOR PREFERENCES FOR MANAGEMENT ACTIONS

Dorothy H. Anderson and Michael J. Manfredo

ABSTRACT: Data were analyzed from previous visitor use studies in wilderness areas and wild river areas to find out what kinds of management actions visitors prefer and to find out whether visitors to two different kinds of resources prefer similar actions. Findings show that visitors support both direct and indirect management actions. When overuse is a problem, direct actions are preferred; otherwise indirect actions are preferred. Visitors to both types of resources tend to prefer the same actions. Implications for managers include a) the need to communicate clearly to visitors the reasons for a proposed action, and b) similar management strategies would seem appropriate for both types of resources.

INTRODUCTION

Providing high-quality recreation opportunities is a primary goal of resource management. The success of that goal depends largely on the management techniques identified and put into practice for a particular resource. In selecting recreation management techniques, managers must question how effective the technique is likely to be, how predictable are its results, what might be its external or unintended effects, how well it fits with the area's history of management, how well it fits with agency character, mandate, and policy, and finally, how the technique is likely to be accepted (or rejected) by area visitors.

The intent of our paper is to provide general information on visitors' support for a variety of management techniques that are appropriate for primitive or wilderness areas. A secondary objective is to find out whether visitors to two different kinds of wild areas prefer the same kinds of management actions. The data presented in the paper are a summary of visitors' preferences for a variety of management techniques and are representative of findings from visitor surveys conducted between 1978 and 1980 at three western wilderness areas and three wild river stretches in the western U.S.

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STUDY AREAS

Three Forest Service primitive and wilderness areas, the Popo Agie Primitive Area and the Bridger and Fitzpatrick Wildernesses, were included in this study. All three areas are located in western Wyoming. In addition, three rivers managed by the Bureau of Land Management were included: the Lower Salmon in Idaho; the Upper Owyhee in Idaho, Nevada, and Oregon; and, the Lower Owyhee in Oregon.

The wilderness areas are similar in that they are high mountain areas characteristic of the Rocky Mountains. At lower elevations are thick stands of conifers segmented by rushing freestone streams; at higher elevations are fragile mountain meadows. The areas are dotted by high mountain lakes offering quality camping locations and excellent fishing opportunities. The rugged terrain offers challenges to hikers and mountain climbers and outstanding scenery to all wilderness travelers.

The rivers are similar in that they all originate in high mountain areas and are fed by spring snowpack melts and rainfall. Each of these rivers cuts through rugged mountain terrain and opens onto rolling to flat landscape at lower elevations. Access is limitied to all of these rivers and opportunities for wilderness kinds of experiences abound. The rivers offer challenges to whitewater enthusiasts at all skill levels and, as with the wilderness areas studied, outstanding scenery to all who visit.

At the time the data were gathered, reported use of all six resource areas was light, but signs were evident that use was increasing. Also, few use restrictions were in place but managers were considering restrictions if impacts from increased use warranted them.

Both the wilderness areas and the river stretches studied vary in size (table 1). The largest wilderness area, the Bridger, occupies 383,300 acres. About one-half its size is the Fitzpatrick and the Popo Agie is about one-fifth the size of the Bridger. The longest stretch of river studied was the Lower Salmon (101 miles); the shortest river stretch studied was the Lower Owyhee (40 miles).

As might be expected, use varies greatly across areas. Based on use statistics available at the time of the studies, the greatest number of visitor days was recorded for the largest wilderness area, the Bridger, and the longest stretch of river, the Lower Salmon. The two largest areas also had the greatest number of visitor days per acre (.49) and visitor days

per mile of river (222.77). Compared to similar areas across the country (Hendee and others 1978) these numbers suggest moderate to light use of the study areas.

Table 1.--Recreation use and size of study areas

Study Area	Size[1]	Visitor Days Related to Size[2]	Total Visitor Days
Wilderness			
Bridger	383,300	.49	187,200
Fitzpatrick	176,303	.16	28,700
Popo Agie	71,320	.47	33,700
River			
Lower Salmon	101	222.77	22,500
Upper Owyhee	80	14.37	1,150
Lower Owyhee	40	132.70	5,308

[1]Wilderness size is measured in acres, river is length in miles.
[2]Wilderness areas are measured in visitor days per acre, river areas are measured in visitor days per mile of river.

METHODS

Data Collection

Data for the wilderness areas were collected during the summer of 1978 by researchers at Colorado State University, Fort Collins, Colorado. River data were gathered during the summers of 1979 and 1980 by Forest Service researchers at the North Central Forest Experiment Station, St. Paul, Minnesota. Data collection for both wilderness areas and rivers was by mail questionnaire. The wilderness and river questionnaires differed, however. The wilderness questionnaire contained 56 management items and the river questionnaire contained 29. Items included in each questionnaire were derived from discussions with managers of the areas, review of public involvement information (when available), review of pertinent literature, and pilot and pretesting of items on a sample of visitors. A total of 29 wilderness management items and 26 river management items were included in this study.

Questionnaires were mailed to visitors shortly after their trips. Wilderness area visitors received questionnaires during the 1978-1979 fall-winter period. Floaters on the Lower Salmon were mailed questionnaires during the fall of 1979 and floaters on both stretches of the Owyhee received questionnaires during the fall of 1980. Two follow-up questionnaires were sent to visitors in each study area. Response rates ranged from a high of 85 percent on the Lower Owyhee River to a low of 59 percent on the Popo Agie Primitive Area (table 2).

Table 2.--Questionnaire response rates for each study area

Study Area	Number Sampled	Number Responded	Percent Responded
Bridger	171	135	79
Popo Agie	160	95	59
Fitzpatrick	103	77	75
Lower Salmon	344	277	81
Upper Owyhee	216	142	66
Lower Owyhee	217	184	85

Sampling

The sample of wilderness users was drawn from names and addresses of visitors collected as the visitors exited each of the wilderness study areas. Additional names and addresses were obtained from the Bridger by distributing stamped, addressed postcards on the windshields of visitors' cars parked at the trailheads. A random sample of river floaters was drawn from visitors' names and addresses collected at river access points. Most of the wilderness users contacted were hikers and most of the floaters who responded were traveling in nonmotor-powered watercraft.

Data Analysis

For each item respondents were asked to indicate to what extent they would support or oppose a particular management action. The wilderness questionnaire used a nine-point scale and the river questionnaire used a five-point scale. Both scales had a central point indicating a neutral response.

In this paper we were interested in making general statements about visitor preferences for management actions across a variety of settings. To do this we first generated frequencies for each potential management action in each area. Next we conducted chi-square tests to see if respondents in one wilderness area differed in their management preferences from respondents in the other two wilderness areas, and if respondents in one river area differed from respondents in the other river areas. Finding no significant differences, we aggregated the data for the three wilderness areas and generated frequencies and percentages for each management preference item. We did the same with the river data. Because we were interested in respondents' general support or opposition to potential management actions, we collapsed their responses to fit a trichotomous variable--support, neutral, oppose.

Using definitions developed by Gilbert and others (1972), we designated each management item as either a "direct action" or an "indirect action". We then assigned each item to one of four management themes (Knopf and Lime 1984): use restrictions, visitor information,

protection and enforcement, and facilities (site) development and improvement. As it happened, items listed under use restrictions and protection and enforcement were all direct kinds of management actions, and items under the other two themes were all indirect actions.

VISITOR PREFERENCES FOR MANAGEMENT ACTIONS

Direct Actions

Use Restrictions.--Because of the diversity of items assigned to this theme, five subthemes were developed to aid discussion. For each of the five subthemes--campsite restrictions,

Table 3.--Visitor preferences for use restrictions

Management Action	Area[1]	Percent Oppose	Percent Support
USE RESTRICTIONS			
Camping Restriction			
Restrict the number of designated campsites near heavily used lakes	W	15	74
Prohibit overnight camping in certain areas	W	45	38
Prohibit camping within 100 feet of lakeshore	W	63	32
Allow camping only at designated locations	R	59	27
Require a permit that states where you may camp	W	74	19
Prohibit camping along the river	R	97	<1
Camp Fire Restrictions			
Allow wood fires only at designated spots	R	37	47
Designate lakes where campfires are allowed	W	41	46
Prohibit fires	W	63	28
Prohibit wood fires altogether	R	81	8
Anti-Litter Regulations			
Require people to carry out their own trash	R	2	96
Prohibit the use of cans, bottles, and other nonburnable disposable containers	R	69	16
Party Size and Type Restrictions			
Prohibit more than 10 horses per party	W	4	88
Allow horse riders and pack animals at certain campsites	W	10	82
Restrict party size to 10 or fewer people	W	10	80
Prohibit off-road vehicles in the vicinity of the river except on roads and highways	R	9	80
Restrict horse riders and pack animals to certain trails	W	8	79
Prohibit motorized watercraft on the river	R	14	74
Allow large groups only in certain areas	W	16	72
Limit the number of people per group allowed on the river	R	40	46
Access			
Prohibit use of heavily used trails	W	16	69
Establish a permit system that regulates the number of camping parties in heavy use areas	W	25	66
Place a daily limit on the number of recreationists that can enter on a given trail	W	35	55
Set restriction quotas for entrance to an area even if you are the one denied entrance	W	36	54
Set trail quotas on weekends and holidays	W	33	50
Restrict the number of people using the river at any one time	R	33	49
Assign the time of day when each group may begin its trip to achieve better spacing among groups	R	47	24

[1]W means wilderness area and R means river area.

campfire restrictions, party size and type restrictions, access restrictions, and anti-litter regulations--we looked at the percent of visitors who supported and opposed each item (table 3). For campsite restrictions we found that although a third or fewer visitors to both kinds of areas would support actions to restrict camping, at least three-fourths of the wilderness visitors would support restricting the number of campsites near heavily used lakes. For campfire restrictions wilderness users and river floaters are about evenly divided in their preferences for management actions that would designate locations where campfires are allowed. On the other hand, both visitor groups overwhelmingly oppose prohibiting fires altogether.

We had two items on the river questionnaire about anti-littering behavior. River floaters overwhelmingly support management actions that would require people to carry out their own trash. River floaters were not likely, though, to support management actions that would prohibit the use of cans, bottles, and other nonburnable disposable containers. Opposition to the latter action might arise from the inconvenience of this action to the floater--repacking foods and beverages in acceptable containers.

More wilderness visitors (80 percent) than river floaters (46 percent) support party size limits. Both wilderness and river visitors, though, were likely to support actions to restrict the kind of party allowed in an area. That is, wilderness hikers support restricting horse parties and river floaters support restricting motor parties, just as previous research has shown (Lucas 1964; Stankey 1973; Anderson and Foster 1985).

Visitor preferences are mixed toward management actions that restrict access to an area or places within an area. About two-thirds of the wilderness visitors support actions to limit access to heavily used trails and heavily used camp areas. Only about half of the river floaters and wilderness visitors support actions to limit access in general to an area.

Protection and Enforcement.--We had two items for rivers and for wilderness areas that tested visitor preferences for protection and enforcement of regulations (table 4). Unlike our findings for use restrictions where visitors to both kinds of resources generally agreed on their preferences for management actions, we found that regarding protection and enforcement, wilderness visitors and river floaters perceived management actions very differently. Wilderness visitors support management actions that would result in more protection and enforcement such as increasing the number of backcountry patrols. In contrast, slightly more than half of the river floaters oppose efforts to provide more patrols and enforce regulations.

Indirect Actions

Visitor Information.--When we looked at potential management actions related to information (table 5), we found that support depended on how the visitor could gain the information. For example, from 74 percent to as many as 90 percent of the visitors support managers' efforts to inform them about the area when it is done through brochures, maps, and pamphlets, and, when the information is available to them before they enter the resource area. Visitors are not as supportive of managers' efforts to provide information if it means the information will be posted in the resource area. In fact, about half of the visitors oppose posting information in the resource areas. The only exception to this latter statement appears to be that about two-thirds of the wilderness visitors would support posting directional signs in wilderness areas.

Other studies have shown that the primary concern of visitors when they enter an area is having a good mental plan for using facilities and recreational opportunities (Ormrod 1984). In particular they want their plan to include information about major attractions, the layout of the area, and information on camping, wildlife, and rules and regulations. Also, Ormrod points out, visitors want to have a detailed map of the area available to them Additionally, the visitors' psychological

Table 4.--Visitor preferences for protection and enforcement actions

Management Action	Area[1]	Percent Oppose	Percent Support
PROTECTION AND ENFORCEMENT			
Place heavy fines (>$50) for violations of wilderness regulations	W	11	82
Increase the number of backcountry rangers for stronger enforcement of regulations	W	20	62
Enforce safety rules and regulations more aggressively	R	28	29
Provide more patrols to assist river users and enforce regulations	R	53	16

[1]W means wilderness area and R means river area.

well-being is enhanced if visitors are adequately oriented to an area before they enter the area. And, inadequate orientation can lead to a less than satisfying recreation experience.

Facilities (Site) Development and Improvements.--In general fewer than half of the wilderness visitors and river floaters support actions for facility developments or improvements (table 6). The only exception is that 90 percent of the wilderness visitors support efforts to revegetate areas made bare by campers. Actions visitors are likely to oppose include those that add more campsites, more parking spaces at access points, and more access points. And visitors are likely to oppose actions that introduce permanent structures--such as pit toilets--into a wilderness setting.

DISCUSSION

Hendee and colleagues (1978) have suggested that managers should give priority to indirect types of management actions in wilderness planning because it retains important elements of freedom in the visitors' wilderness experience. We agree with this suggestion and believe that in most instances so would visitors. However, we would add that there are times when visitors strongly support direct actions and do not support indirect actions. Actions that visitors choose to support depend partly on when the action occurs, the reason for the action, the action itself, and whom the action affects.

In general we found that visitors were likely to support management actions, direct or indirect, that retain the quality and character of the

Table 5.--Visitor preferences for information

Management Action	Area[1]	Percent Oppose	Percent Support
INFORMATION			
Make information pamphlets stating regulations in the wilderness	W	2	90
Make an easily obtainable pamphlet describing the natural flora and geology of the area	W	5	84
Make easily obtainable maps showing campsites in the area according to how heavily used they are	W	8	82
Make readily obtainable maps of the wilderness	W	13	74
Ensure well-maintained directional signs	W	13	68
Place signs stating regulations on the trail near lakes	W	38	46
Make an easily obtainable information packet describing good fishing opportunities	W	29	44
Post signs warning and advising hazards	R	49	30
Provide more information along the river identifying facilities and points of interest	R	41	29
Provide more distance markers along the river	R	49	25
Construct directional signs with no mileage indicated on them	W	49	24

[1]W means wilderness area R means river area.

Table 6.--Visitor preferences for facilities (site) development and improvements

Management Action	Area[1]	Percent Oppose	Percent Support
FACILITIES (SITE) DEVELOPMENT AND IMPROVEMENTS			
Revegetate areas made bare by campers	W	3	90
Provide campsites for river users at put-in and take-out points	R	23	46
Harden or reinforce highly used campsites	W	34	46
Construct outhouse type toilets at popular campsites	W	45	41
Develop short hiking trails at points along the river	R	36	39
Improve existing access roads to put-in and take-out points	R	35	32
Improve the loading areas at put-in and take-out points	R	27	25
Provide more campsites along the river between put-in and take-out points	R	47	21
Provide more parking at access	R	42	11
Provide more points of public access to the river	R	81	9

[1]W means wilderness area R means river area.

resource and recreation experience. For example, hikers and floaters support use restrictions in heavily used areas, support efforts to revegetate areas made bare by overuse, and support efforts to provide visitors with pre-trip information about the resource and use regulations. But they oppose actions that would result in signs or other markers being placed in the area, more access points or facilities at access points, and efforts to generally restrict visitor behavior within an area. An exception to this latter statement is that wilderness visitors are more likely to support party size limits than river users are. We do not know why this is but hiking parties in the study areas are traditionally small groups (fewer than 10 people), whereas river floating parties vary greatly in size, partly because of the variety of watercraft and the watercraft's capacity.

We believe these findings point to the importance of communicating the need for management actions to visitors. We know visitors are concerned about a variety of different aspects of their experiences (Anderson 1980; Knopf 1982). And some of their concerns center on problems of depreciative behaviors, resource degradation, and inappropriate visitor uses. Most often managers' actions are designed to offset these problems. At times management actions may curb individual freedoms, and managers may have no choice but to implement decisions that curtail some visitors' freedoms if they are to preserve existing recreation experiences and develop future opportunities (Schreyer 1977). Visitors, though, may not always be aware of managers' intentions and may not always see managers' actions as attempts to increase visitor enjoyment.

Information that explains a manager's reasons for actions would be a positive step toward visitor acceptance of those actions. In a recent study, Oliver and her colleagues (1985) demonstrated that information on use impacts has the potential of reducing impacts by 50 percent if it is distributed and explained to visitors as they enter an area. In our study, when visitors were presented with an action such as restrict camping in an area, they generally opposed it. But, when given additional information that explained the reason for the action--restrict camping in <u>heavily used</u> areas--they tended to support it.

We also found that visitors opposed actions such as constructing pit toilets near heavily used areas, hardening sites, and reinforcing loading areas on rivers. These actions may be reasonable approaches where severe site problems exist. If managers expect visitor support they must clearly state their reason for these actions. It may be that pit toilets in heavy use areas result in better water quality for the area; site-hardening may slow campsite deterioration; and, reinforcing loading areas along rivers may slow streambank erosion. By communicating with visitors, managers are not only assured of making better decisions but they are more likely to make decisions visitors understand and applaud.

A secondary objective of our study was to find out whether visitors support similar kinds of management actions for wilderness areas and wild rivers. Generally, though the resources differed, visitors perceive both as wild areas and support actions they believe are appropriate for wild areas. The most notable exception was for actions related to visitor protection and enforcement of regulations--wilderness visitors tend to support them, river floaters do not. The implication of our findings is that management strategies for both types of resources can be approached in the same way.

REFERENCES

Anderson, D. H. Long-time Boundary Waters' visitors change use patterns. Naturalist. 31(4):2-5; 1980.

Anderson, D. H.; Foster, D. I. Perceived change in a river environment and its effects on visitor use: a case study of Ozark National Scenic Riverways. Western Wildlands. 11(2):21-24; 1985.

Gilbert, G. C.; Peterson, G. L.; Lime, D. W. Towards a model of travel behavior in the Boundary Waters Canoe Area. Environment and Behavior. 4(2):131-157; 1972.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. MP No. 1365. Washington, DC: USDA, Forest Service; 1978. 381 p.

Knopf, R. C. Management problems in river recreation: what river floaters are telling us. Naturalist. 33(2):12-17; 1982.

Knopf, R. C.; Lime, D. W. A recreation manager's guide to understanding river use and users. GTR-WO 38. Washington, DC: USDA Forest Service; 1984. 37 p.

Lucas, R. C. The recreational capacity of the Quetico-Superior area. Res. Pap. LS-15. St. Paul, MN: USDA, Forest Service, No. Centr. For. Exp. Sta.; 1964. 34 p.

Oliver, S. S.; Roggenbuck, J. W.; Watson, A. E. Education to reduce impacts in forest campgrounds. Journal of Forestry. 83(4):234-236; 1985.

Ormrod, R. K. Orienting park visitors. Parks & Recreation. (March):58-63,70; 1984.

Schreyer, R. Restricting recreational use of wildlands: lessons from whitewater rivers. Western Wildlands. (Fall):45-52; 1977.

Stankey, G. H. Visitor perception of wilderness recreation carrying capacity. Res. Pap. INT-142. Ogden, UT: USDA, Forest Service, Intermtn. For. and R. Exper. Sta.; 1973. 61 p.

WILDERNESS MANAGERS' PERCEPTIONS OF RECREATIONAL HORSE USE IN THE NORTHWESTERN UNITED STATES

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ABSTRACT: Local managers' perspectives play an important role in deciding what uses will be allowed in wilderness and which techniques will be chosen to control the impacts of such use. Recreational horse use is particularly controversial due to its social and physical impacts. Eighty-six wilderness managers in the northwestern states were surveyed regarding their perceptions of the nature, impacts, and management of horse use.

Despite the impacts attributed to horse use, most managers accepted this use as a valid part of the wilderness experience and preferred to use educational approaches to control impacts rather than more direct regulatory methods. Managers provided several recommendations for management of horse use in wilderness.

INTRODUCTION

Legislation and agency policy provide a broad framework for the management of wilderness areas. Because each area is unique, most of the decisions affecting the land and its use must be made by the local managers. Managers' personal perspectives influence both their assessment of recreational impacts and their choice of techniques used to control unacceptable impacts (Hendee and others 1978).

Horse use is particularly controversial in many wilderness areas due to its social and physical impacts. Backpackers often resent the presence of horses (Lee 1975; Robinson and others 1979). Horses generally cause more severe impacts upon the area than hikers. Facilities for horses concentrate impacts (Frissell 1973; Hendee and others 1978). Their hooves tend to loosen soil, promoting erosion (Whittaker 1978) and they are particularly damaging to moist areas (Laing 1961; Strand 1972). Trampling and grazing of native flora can unnaturally alter wilderness ecosystems, while horse manure can introduce foreign plant species and contribute to water pollution (Hendee and others 1978).

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On the positive side, horse use is traditional in most western wilderness areas. Horses can carry large loads farther and faster than humans, and provide access to the wilderness for the handicapped and those otherwise incapable or unwilling to endure more rigorous travel. Organized groups of horse users have worked with managers to minimize impacts, haul out trash, and plan and construct facilities (Flick 1979; Robinson and others 1979).

The techniques that managers may use to cope with recreational use impacts may be grouped into five categories:

1. DESIGN AND PLANNING to prevent problems in advance;
2. DIRECT REGULATION through restriction and limitations;
3. INDIRECT REGULATION through manipulation of the resource to discourage use;
4. SITE HARDENING to improve the areas ability to withstand use; and
5. EDUCATION AND INFORMATION DISPERSAL to encourage minimum impact use.

These five categories are a refinement of the regulatory/manipulative dichotomy developed by Gilbert and others (1972) and used by Bury and Fish (1980) and Lucas (1982). In that dichotomy, the last three approaches were included in the "manipulative" category.

Education may be differentiated from other manipulative techniques in that it provides visitors with information to make their own choices, rather than forcing them into a course of action. Education expands choices, rather than narrowing them. This option has gained in popularity (Godin and Leonard 1979) and is considered effective by many managers (Buscher 1979; Kneelund 1981; Petzoldt 1974). Bradley (1979, 1981) has had success in the Eagle Cap Wilderness of northeastern Oregon with a blend of personal contact and education that he calls "the Human Approach."

In 1981, a study investigating the nature of wilderness managers' perceptions of recreational horse use was initiated. Specifically, the study sought to:

1. Describe the nature and extent of wilderness horse use as perceived by managers.

2. Identify the management problems they associated with horse use.

3. Identify the various management responses deemed appropriate to control these problems.

4. To correlate managers' backgrounds with their attitudes towards horse use and towards various management responses.

5. To make recommendations for the management of horse use in wilderness based upon a consensus of managers' experience.

METHODS

The design and methodology of the study was patterned after Moutsinas' (1976) study of forest managers' perceptions, differing in that a larger geographic region (four states instead of two) and a more specialized population (wilderness managers) were polled. Moutsinas' study utilized a mail-back questionnaire consisting of alternative choice, open-ended, and rating scale questions. The 10-page mail questionnaire designed for this study was distributed to 86 wilderness managers in Washington, Oregon, Idaho and Montana, with a 94% response rate.

Two hundred seven variables were examined. In the analysis, these were grouped into four parts:

1. Managers' personal background descriptors.

2. Managers' views of current state of horse use on their areas.

3. Reasons given by managers in support of their views.

4. Managers' preferences for particular management techniques.

These data were cross-tabulated using the same three statistics used by Moutsinas (1976): chi-square, to determine the existence of a systematic relationship between two or more variables; gamma, to determine the nature of the relationship; and asymmetric lambda, to determine the ability to predict one variable using another.

RESULTS

Wilderness Manager's Profile

Most (87%) of the wilderness managers responding in this study were employees of the U.S. Forest Service; 9% worked for the National Park Service, 3% for the Fish and Wildlife Service and 1% for the Bureau of Land Management. Two-thirds (68%) had worked for their agency 10 years or longer. Eighty-one percent held a bachelor's or higher degree in some area of resource management. Wilderness management was considered one of several major responsibilities by 63% of the managers, while 27% viewed wilderness management as their primary task. The managers listed 37 specific job titles for their positions: wilderness, backcountry, dispersed recreation, or recreation occurred in 49% of these.

Most managers (90%) currently enjoyed trail riding; 57% listed horseback riding as a personally preferred recreation activity. More than a third (38%) owned or had recently owned a horse and 73% indicated that they rode horses in the course of their job.

Managers' Perceptions of the Current State of Horse Use

Seventy percent of the managers agreed that horse use is appropriate in wilderness. However, because of the small percentage of horse-using visitors (most managers estimated horse use to constitute 10% or less of total visitation), 49% ranked horse use as less important than other types of recreation on their areas. Fifty-two percent believed that levels of horse use had remained constant on their areas over the last 5 years, while 37% believed that it had increased. The presence or absence of facilities such as corrals was one of the major factors managers believed contributed to the growth or decline of horse use. Agency policy was perceived by two-thirds of the respondents as encouraging horse use.

The majority of managers characterized horse users as being experienced horsemen, using their own stock, and traveling in groups of five or fewer persons. Most equestrians were considered knowledgeable about wilderness values and cooperative with management efforts, except for low compliance in securing wilderness use permits.

Seventy-four percent of the managers perceived benefit accruing from horse use in their areas. However, from a list of seven possible benefits to managers, 43% recognized three or less, and no manager recognized more than five. Those most frequently cited were trail maintenance, minimum impact education of other horsemen, facility construction, volunteer search and rescue, providing assistance to distressed hikers, and trash haulout. Many of these management benefits derive from actions taken by horsemen to serve their own interests, such as trail maintenance and facility construction.

Managers considered wilderness horsemen to be attracted primarily by opportunities for hunting and primitive travel in large roadless areas. These attractions were followed by opportunities to enjoy scenic beauty, fishing, and wilderness camping, with the horse considered merely as transportation, rather than central to the experience. Managers accepted most of the recreational activities pursued by horsemen; however, those activities involving large groups (over 10 horsemen), off-trail riding, extended visits (over 14 days), and semi-permanent base camps were not accepted.

Outfitters were perceived by most managers as accounting for less than half of all use, and representing less than 10% by over half of the managers. In most areas, fewer than 10 legal outfitters were reported. Relations between most managers and outfitters were deemed friendly and cooperative.

Three-fourths of the managers surveyed had received complaints about horses. Most were from hikers (59%) and other horsemen (15%), and were most frequently directed at small, independent groups, hunters, and outfitters. The subject of these complaints most often included manure on trails (18%), campsite damage due to stock (14%), trail wear and erosion (12%), trash and litter (11%), meadow damage (6%), and riparian zone damage (5%). When managers were asked to rate the severity of 18 problems commonly associated with recreational horse use in wilderness, they rated problems relating to direct mechanical impacts (compaction, damage to trees, trail erosion) as the most severe (table 1). The seven items most frequently cited as significant by managers included various forms of site, trail, and riparian zone damage as well as hiker resentment of horses (table 2).

Table 1.--Wilderness managers' rating of problems associated with recreational horse use

Problem	A Serious Problem	Somewhat of a Problem	Not Really a Problem
Damaged trees due to picketing	29.6%	49.4%	21.0%
Soil compaction at campsites	14.8	53.1	32.1
Trail erosion & dust	12.3	59.3	28.4
Meadow damage	9.9	37.0	53.1
Hiker resentment of horses	7.4	55.6	37.0
Manure as a nuisance	6.2	40.7	53.1
Semi-permanent campsites	4.9	45.7	49.4
Physical damage of large organized trailrides	3.7	21.0	75.3
Concentrations of trash at horse-use campsites	3.7	50.6	45.7
Overgrazing (competition with native fauna)	3.7	30.9	65.4
Nonnative plant introduction	2.5	30.9	66.7
Water pollution	2.5	22.2	75.5
Intrusion on others' solitude	2.5	21.0	76.5
Safety of horse use	1.2	12.3	86.4
Manure as a health hazard	1.2	9.9	88.9
Increased fire risks	1.2	9.9	88.9
Harassment of wildlife (not including legal hunting)	1.2	1.2	97.5
Unauthorized use of closed areas and trails	1.2	9.9	88.9

Table 2.--Seven items most frequently cited by managers as being the most significant horse-related problems in their areas

	Percentage[1]
Damaged trees due to picketing	49.3
Trail erosion and dust	38.3
Soil compaction at campsites	37.0
Riparian zone damage	34.5
Concentrations of trash at horse campsites	22.2
Hiker resentment of horses	19.7
Semi-permanent campsites	17.3

[1] Percentage of the respondents that included this item as one of their three most significant problems.

Seventy-nine percent of the managers believed that "ignorance of proper backcountry skills" was the major cause of horse-related impacts. Specifically, the lack of backcountry experience by both users and their animals was perceived as a cause of many problems. Poor restraint practices can result in unnecessary site damage, and inexperienced, "panicky" animals can cause undue resource damage even when proper minimum impact techniques are used.

Managers' Preferences for Horse Management Techniques

Twenty-one techniques for managing recreational horse use impacts on wilderness were evaluated by managers. These have been grouped into the five technique categories and arrayed from most to least favored by the managers (table 3).

Developing and implementing a minimum-impact education program and publicizing alternative areas for horse use were the techniques favored by the most managers. Site manipulation was another manipulative technique favored by more managers than any of the regulatory techniques. These data suggest that managers favor manipulative approaches to management (particularly categories 4 and 5) over regulatory. However, the favored techniques may not be the ones managers choose to implement. Fish and Bury (1980) found that managers attempting to prevent overuse generally choose manipulative techniques, but when they are responding to existing resource impacts they select a regulatory approach. Fish and Bury (1980) also found that U.S. Forest Service wilderness managers were likely to defer any control until overuse appeared. Regulation is often the chosen approach of U.S. Forest Service wilderness managers. This has raised questions concerning the impact of regulations on the wilderness experience (Lucas 1982). Data from our study indicate that managers actually favor manipulative techniques to control the impacts of recreational horse use. The challenge is to convince and to train managers to use manipulative techniques like minimum-impact education more effectively.

Table 3.--Wilderness managers' preference for recreational horse use management techniques

	Percentage		
	Favor	Neutral	Oppose
1. DESIGN AND PLANNING to prevent problems in advance			
Build new trail to underused areas in hope of relieving congestion	28.4	25.9	45.7
Develop special trails and facilities to localize impacts of horse use.	28.4	25.9	46.9
2. DIRECT REGULATION through restriction and limitation			
Limit total number of horses in an area at one time	72.5	11.2	16.2
Close overused areas and trails	70.4	13.6	16.0
Limit length of stay equally for all wilderness users	61.7	21.0	17.3
Require horsemen to carry and use prepared stock feeds	60.5	21.0	18.5
Prohibit horse use at times of high damage potential (early use season, etc.)	54.3	29.6	16.0
Assign campsites and trails on a first-come, first-served basis	43.2	21.0	35.8
Limit total number of horses allowed to enter the area per season	18.5	29.6	51.9
Require reservations, limit number of users in area at one time	17.3	25.9	56.8
Require proof of minimum-impact wilderness skills before admittance	14.8	21.0	64.2
Ration use by limiting number of visits by an individual	13.7	25.0	61.2
Limit length-of-stay for horsemen more than hikers	11.1	13.6	75.3
Charge a special fee for horse use: apply funds to horse-use management	7.4	18.5	74.1
3. INDIRECT REGULATION through manipulation of the resource to discourage use			
Dismantle and remove all corrals, drift fences, and other horse facilities	58.0	21.0	21.0
Make trail access difficult by neglecting access roads	9.9	23.5	66.7
4. SITE HARDENING to improve the areas ability to withstand use			
Rehabilitate overused areas and trails (replanting, etc.)	80.2	13.6	6.2
Maintain or improve all trails for horse use	27.2	7.4	65.4
5. EDUCATION AND INFORMATION DISPERSAL to encourage minimum-impact use			
Develop and implement a minimum-impact education program	91.4	4.9	3.7
Publicize alternate areas for horse use	87.7	7.4	4.9

Managers generally favored regulatory techniques that were flexible, temporary, and responsive to a specific resource need (e.g., overuse, lack of native forage, and fragile sites or season of use). They tended to oppose regulations that were permanent, heavily prejudiced against horse users, and/or rationed use by reservation or limits on the number of visits by an individual.

Several definite relationships between area descriptive variables and management technique preferences were found in the analysis. Managers of large wilderness areas (greater than 250,000 acres) preferred the development of separate horse/hiker zones, pack-in feed requirements, and special horse trails. Managers of areas with long use seasons preferred limitations of total numbers of horses in the area at one time, prohibition of horses in high-risk periods, pack-in feed requirements, and the establishment of special horse trails.

RECOMMENDATIONS FOR THE MANAGEMENT OF RECREATIONAL HORSE USE IN WILDERNESS AREAS

Personal freedom (the lack of regimentation and regulation) is important to the wilderness experience. The Wilderness Act and the management policies of the agencies responsible for wilderness clearly identify this as a management goal. Techniques other than direct regulation should be carefully evaluated before even temporary regulations are selected for implementation (Lucas 1982). Yet, others (Fish and Bury 1980) have found that regulations are more frequently implemented, particularly when managers are responding to existing resource impacts. Our data suggest that managers favor education, information dissemination and other non-regulatory techniques over regulation. This indicates that managers may not be familiar with the existing nonregulatory techniques or they may lack the information on how to effectively implement them. A wilderness workshop for managers focusing on nonregulatory techniques for controlling impacts would be one method of disseminating this information. Researchers should also place greater emphasis on the development and evaluation of nonregulatory techniques. Our data suggest that managers would readily implement these techniques over regulations if they were proven effective.

Managers favor regulatory techniques that are flexible, temporary and responsive to specific and immediate resource needs when dealing with recreation impacts associated with horse use. This could lead to a reactive style of management that solves short-run problems, but results in decisions that are incompatible with the long-term goals and objectives for the wilderness. If temporary regulations are implemented, they should be compatible with the wilderness management plan.

Seventy-nine percent of the wilderness managers surveyed believed that most horse-related impacts were caused by user ignorance of proper backcountry horse handling skills. Lack of experience by both users and horses is also believed to result in much unnecessary impact. These problems could be solved with information and education programs and materials developed by managers and experienced horse users. Educational materials written from the horse user's perspective and focusing on these problems are few and often locally distributed. Our study found that many wilderness managers were unaware of existing materials. Educational materials focusing on the problems associated with recreational horse use need to be reviewed and the production of new materials encouraged. Wilderness managers should be made aware of these materials.

The benefits managers perceive from recreational horse use in their areas include the education of other horse users, facility construction, trail maintenance, search and rescue, and trash haulout. Volunteer horsemen should be recruited and volunteer agreements with horsemen should be encouraged by wilderness managers.

Research has demonstrated that managers' views often differ from those of their clientele (Clark and others 1971; Hendee and Pyle 1971; Lucas 1970, 1979; Peterson 1974). Managers tend to project their views onto the public (Taylor and Catton 1963) and may misjudge user desires and responses to management actions (Clark and others 1971; Downing and Clark 1979; Hendee and Harris 1970). The differences between managers' and users' viewpoints may convert routine resource management decisions into highly charged, emotional reactions (Burch 1964) with deleterious consequences for both. Cooperation is needed between managers and the public as well as with other managers (Buscher 1979; Lucas 1979; Tobin 1979). It is important for managers to seek an understanding of their clientele; in this case, horse users. While this can be gained on an individual level through personal contact, a form of opinion survey producing data comparable to this study could be useful in guiding the formation of agency policy. Such a survey could be distributed through a number of local, regional and national horsemen's organizations. Another alternative for surveying horsemen would be to distribute the questionnaire in cooperation with any of several magazines catering to equestrians, such as Western Horseman. A comparison of the results would likely be of interest to managers and horsemen.

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REFERENCES

Bradley, Jim. A human approach to reducing wildland impacts. In: Proceedings, recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, R-6-001-1979; 1979: 222-226.

Bradley, Jim. Editorial. Impact; the wilderness news. Enterprise, OR: U.S. Department of Agriculture, Forest Service, Wallowa-Whitman National Forest, Eagle Cap Wilderness. 2(3): 1; 1981.

Burch, William. Two concepts for guiding resource management decisions. Journal of Forestry. 62(10): 707-712; 1964.

Bury, Richard L.; Fish, Ben C. Controlling wilderness recreation: what managers think and do. Journal of Soil and Water Conservation. 35(2): 90-93; 1980.

Buscher, Richard F. Wildland recreational impact from the U.S. Forest Service land manager's perspective. In: Proceedings, recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, R-6-001-1979; 1979: 11-13.

Clark, Roger N.; Hendee, John C.; Campbell, F. L. Depreciative behavior in forest campgrounds: an exploratory study. Research Note PNW-161. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1971. 12 p.

Downing, Kent; Clark, R. N. User's and manager's perceptions of dispersed recreation impacts: a focus on roaded forest lands. In: Proceedings, recreational impact on wildlands conference. 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, R-6-001-1979; 1979: 18-23.

Flick, J. Earl. Efforts of equestrians to protect wildlands. In: Proceedings, recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, R-6-001-1979; 1979: 195-198.

Frissell, Sidney S. The impact of wilderness visitors on natural ecosystems. Missoula, MT: Final report to the U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 60 p.

Gilbert, G. C.; Peterson, G. L.; Lime, D. W. Towards a model of travel behavior in the Boundary Waters Canoe Area. Environment and Behavior. 4: 131-157; 1972.

Godin, Victor B.; Leonard, Raymond E. Management problems in designated wilderness areas. Journal of Soil and Water Conservation. 35(3): 141-143; 1979.

Hendee, John C.; Harris, R. W. Forester's perception of wilderness-user attitudes and preferences. Journal of Forestry. 68(12): 759-762; 1970.

Hendee, John C.; Pyle, R. M. Wilderness managers, wilderness users: a problem of perception. Naturalist. 22(3): 22-26; 1971.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Miscellaneous Publication No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Kneeland, David T. Educational programs to reduce impact upon wildlands. Recreation Resources Management Bulletin. 1(2): 18-21; 1981.

Laing, C. C. A report on the effect of visitors on the natural landscape in the vicinity of Lake Solitude, Grand Teton National Park. Unpublished report on file at: U.S. Department of the Interior, National Park Service, Grand Teton National Park; 1961. 62 p.

Lee, Robert G. The management of human components in the Yosemite National Park ecosystem. San Francisco, CA: Final research report of the Yosemite Institute for the U.S. Department of the Interior, National Park Service; 1975. 134 p.

Lucas, Robert C. User evaluation of campgrounds on two Michigan National Forests. Research Paper NC-44. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1970. 15 p.

Lucas, Robert C. Perceptions of non-motorized recreational impacts: a review of research findings. In: Proceedings, recreational impact on wildlands conference; 1978 October 27-29: Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, R-6-001-1979; 1979: 24-31.

Lucas, Robert C. Recreation regulations--when are they needed? Journal of Forestry. 80: 148-151; 1982.

Moutsinas, Cynthia M. Attitudes of forest managers toward dispersed recreation on roaded lands in the Pacific Northwest. Corvallis, OR: Oregon State University; 1976. 107 p. M.S. Thesis.

Peterson, George L. A comparison of the sentiments and perceptions of wilderness managers and canoeists in the Boundary Waters Canoe Area. Journal of Leisure Research. 6(3): 194-206; 1974.

Petzoldt, Paul. The wilderness handbook. New York: W. W. Norton and Company; 1974. 186 p.

Robinson, Loy; Caldwell, Bob; Wilcox, Ken. Backcountry horsemen. In: Proceedings, recreational impacts on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, R-6-001-1979; 1979: 326-328.

Strand, S. Pack animals impact: progress report on pack animal impact on wilderness meadows. In: Wilderness impact study report; San Francisco, CA: Outing Committee, Sierra Club: 1972: 37-48.

Taylor, D.; Catton, W. R., Jr. Problems of interpretation in clinical sociology. Sociological Inquiry. 33: 3; 1963.

Tobin, Daniel J. Wildland recreational impact from the National Park Service land manager's perspective. In: Proceedings, recreational impact on wildlands conference; 1978 October 27-29; Seattle, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; R-6-001-1979; 1979: 8-10.

Whittaker, P. L. Comparison of surface impact of hiking and horseback riding in the Great Smoky Mountains National Park. Report to the U.S. Department of the Interior, National Park Service, Southeast Region. Report no. 24; 1978. 32 p.

ACTUAL VERSUS SELF-REPORTED WILDERNESS VISITOR BEHAVIOR

Rachel D. Robertson

ABSTRACT: The accuracy of self-reported wilderness camping behavior was examined by comparing self-reported behavior with actual behavior. Factors that may influence accuracy of self-reported behavior were identified by examining the relationship between self-report accuracy and selected visitor characteristics. Simultaneous measurements of self-reported behavior, visitor characteristics, and actual behavior were made through questionnaires and direct, systematic observations of behavior and behavior traces. Visitors were quite accurate in responding to discrete behaviors. Response error was greater for estimating continuous measures on an interval scale. Visitor characteristics provided little explanation for the variance in visitor response error.

INTRODUCTION

Determining what wilderness visitors do is of growing importance to wilderness managers because users are an integral part of policy formation (Lucas and Oltman 1971). Hendee and others (1978) expressed a need to strengthen the behavioral component of wilderness research by focusing more heavily on what people actually do, not just what they say they would do or how they feel.

According to Stankey (1979) in his analysis of social behavioral research, information about the actual behavior of individuals and groups should generally be collected by direct measures, using techniques other than self-report. The implicit reason for studying actual behavior is that self-report methodology is problematic in nature due to the question of "words" versus "deeds." Do people respond truthfully or accurately when reporting their own behavior? The object of social science research is to understand and even predict behavior, yet we rarely study overt behavior (Deutscher 1966). From our self-reported responses we generally obtain statements of attitude, opinion, norms, values, anticipation, or recall. As researchers we often oblige policy makers by assuming that verbal responses reflect behavioral tendencies (Deutscher 1966).

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Past investigations of leisure services indicate that response scores on self-report surveys do not accurately reflect actual behavior. H. K. Hancock (1973) found limited agreement between expressed opinion and ultimate behavior regarding preferences in campground vegetation. He concluded that disagreement between what campers said and their observed behavior tends to make opinions suspect as reliable indicators of preference. Chase and Harada (1984) studied response error in self-reported recreation participation and found a large response overestimation of actual participation. Shelby and Colvin (1982) found that recall reports of visitor encounters are accurate only at low encounter levels; at higher levels users underreport by about half. Robert G. Lee (1977) found no association between backcountry visitor attitudes toward crowding and observed social interaction or behavior to avoid such social interaction. Lee concluded that subjective responses of visitors measured by questionnaires and interviews are often of debatable validity.

No studies were found comparing self-reported and actual camping behavior of wilderness users. Therefore it would be valuable, for both social scientists and wilderness managers who are attempting to understand wilderness behavior, to know if traditional self-reported responses are reliable and valid indicators of actual behavior.

The purpose of this study was to examine the accuracy of self-reported wilderness camping behavior by comparing self-reported behavior with actual behavior. A secondary purpose was to identify factors that may influence accuracy of self-reported behavior by examining the relationship between self-report accuracy and selected visitor characteristics. Simultaneous measurements of self-reported behavior, visitor characteristics, and actual behavior were made through questionnaires and direct, systematic observations of behavior and behavior traces by a trained researcher.

METHODOLOGY

As a result of the preceding literature review, it was hypothesized that self-reported behavior would be incongruent with actual behavior. The extent and nature of the incongruence was not predicted due to limited previous research using systematic observation of wilderness camping behavior.

For purposes of this study, wilderness camping behavior was conceptualized as overt behaviors that can either minimize or maximize impact on wilderness areas. Studied self-reported and observed behaviors included campfire techniques, disposal of unburnable trash, method of tying stock, and distance of campsite from a water source and trail. Campfire techniques included the type of fire used (wood or stove). If a wood fire was used, additional behaviors investigated were source of wood, use of existing fire rings, method of building fire, and naturalization techniques. Criteria for selection of these behaviors included: potential for unobtrusive direct observation, and degree of potential impact on the wilderness environment.

In order to investigate the relationship between self-report accuracy and visitor characteristics, the survey included questions regarding: method of travel, length of stay, party size, visitor activities, education, occupation, gender, age, income, and party composition (alone, with friends and/or family, or organized group). A review of wilderness recreation literature that reported visitor characteristics provided criteria for selection of these variables (Hendee and others 1978).

The method used for data collection was participant observation (Campbell 1970). Participant observation has been effectively used for measuring social interaction of backcountry users (Lee 1977), recreation encounters (Shelby and Colvin 1982), recreation activities (Hendee and others 1977), and use levels, campsite selection, and visitor characteristics (Heberlein and Dunwiddie 1979).

LOCATION

The study took place at three locations in the Three Sisters and Mount Washington Wilderness Areas, which are adjacent areas in the Willamette National Forest of central Oregon. These locations were chosen because of their popularity for a variety of wilderness recreation uses, the ease of observing campsites along lake shores and above timberline, and the researcher's familiarity with the study sites. A variety of site types and locations were visited to ensure representation of the most popular activities in the area, namely hiking, fishing, mountain climbing, and travel by horseback. The three study locations included: Sunshine Meadows, a high alpine area in the Three Sisters; Mink Lake, in the southern region of the Three Sisters; and Benson and Tenas Lakes, in the southern region of Mount Washington Wilderness.

DATA COLLECTION

Data collection took place from July 2 to August 8, 1984. The researcher, accompanied by a research assistant, began the study with identification of approximately 15 to 20 campsites at each study location. Campsites were chosen based on ease of observation and distance from the observer's base camp. Mink Lake is approximately 3 miles in circumference and all campsites on the lake were selected. Benson and Tenas Lakes are 1 mile apart and each has from 10 to 15 campsites. Again, all campsites were studied. All Sunshine Meadow campsites within an approximate 2-mile radius were studied, with all but four campsites included in a fire ban.

The second step was to observe campsite conditions prior to the visitor's arrival. Records were kept regarding traces of fire ring, litter, and anything unusual that was the result of previous visitor activities, such as trees scarred from horses, or chopped wood.

In the evening of the visitor's arrival or the following morning, the researcher visited the campsite and observed use of campfire or stove, fire ring, chopped wood, location of tent, and method of tying stock. All party members 8 years of age and older were asked to complete a short questionnaire that measured the aforementioned behaviors and visitor characteristics. Respondents were informed that the purpose of the study was to better understand wilderness visitor activities. They were not informed of the preceding or followup observations for traces of behavior.

As Lucas and Oltman (1971) pointed out, contacting people in the wilderness may be an unwelcome intrusion into the solitude that some visitors are seeking. However, "those who have used this technique say they have not sensed resentment" (Lucas and Oltman 1971, p. 29). In keeping with their observations and conclusions reached after use of similar backcountry sampling strategies in the Three Sisters (Robertson 1981), minimal resentment was expressed by the wilderness visitors. After learning the nature of the research and understanding its management implications, visitors were generally eager to cooperate.

After the visitors moved from the campsite, new behavior traces were observed and the campsite distance from the nearest water source and trail was measured. Traces of campfire techniques were observed including: new ashes from a wood fire; use of existing fire ring; whether the fire was built in a shallow pit or on the ground; disposal of ashes; naturalization of fire ring; and evidence indicating source of wood (such as new scars on nearby trees). Pieces of litter in the fire ring and on the campsite were observed. Campsite distance was measured from the point of the tent or fire ring closest to the trail and water by using a rope marked at 1-foot intervals. Parties vary in terms of where they pitch their tents and some campsites have several possible tent locations; therefore, it was necessary to measure after each visit. The researcher attempted to be unobtrusive by observing and measuring campsites in the late morning when no visitors were nearby. Observations were systematically coded for each party and were used in the data analyses to compare actual to self-reported behavior.

VISITOR PROFILE

The sample included 171 backcountry visitors, representing 45 parties. The response rate was 100 percent. Seventy-four percent (N = 125) of the observed parties stayed 1 or 2 nights in the wilderness. On the basis of behavior, conversation with party members, and equipment, parties were classified into three groups; anglers (11 percent), climbers (24 percent), and hikers (65 percent). Most parties (82 percent) were composed of four or less members; however 9 percent of the parties had 10 or more members. Informal groups of family and friends represented 67 percent of all visitors; 32 percent were part of organized groups, and one percent were traveling alone. The visitors tended to be young, (45 percent less than 30 years old), professionals (44 percent), with a moderately high income (50 percent earned over $25,000), and college graduates (56 percent). Full-time students were 23 percent of the sample. One-third of the visitors were female. Only seven campers (4.1 percent) traveled by horseback. The majority of data (67 percent) was collected Friday through Sunday. Thirteen percent of the visitors camped in the high-elevation lake region of Mount Washington Wilderness, another 13 percent camped near low-elevation Mink Lake in the Three Sisters, and the remaining 74 percent visited the high alpine area of the Three Sisters. Distance of campsite from trail and water could not be measured for 38 and 33 visitors, respectively, due to heavy snow cover. These cases were not included in the correlations between actual and self-reported distances from trail and water.

RESULTS

The individual rather than the party was the unit of analysis for this study, as the research problem focused on accuracy of individual responses regarding camping behavior rather than preferences for behavior or decision-making responsibility for the given behavior. A stepwise multiple regression controlling for party size was performed to determine the possible influence of party size on reported responses. The results were not statistically significant.

The relationship between self-reported camping behavior and actual behavior was explored by using the Pearson's Product Moment correlation ($\underline{r}$) for the distance camped from a trail or water source. There appeared to be some major differences between the two measures of behavior. The correlation between actual and self-reported campsite distance from a trail was 0.57 ($\underline{p} \leq 0.001$), and from a water source was 0.71 ($\underline{p} \leq 0.001$). Thirty-five percent (N = 46) and 48 percent (N = 66) of the visitors were accurate in reporting distance from a trail and water, respectively.

The relationship between actual and self-reported campsite location is shown in more detail in tables 1 and 2. Thirty-four percent of those individuals camping less than 25 feet from a trail were accurate in their reported measurement, while 53 percent reported 26 to 100 feet (see table 1). Conversely, 53 percent of the persons camping over 300 feet from a trail reported less than or equal to 200 feet. There seems to be a tendency to overestimate the shorter distances and underestimate the longer distances.

Table 1.--Accuracy of reported campsite distance from trail[1, 2]

Self-reported distance	Actual distance in feet						
	0-25	26-50	51-100	101-200	201-300	Over 300	Total
Feet	Percent[3]						n
0-25	**34**	50	14	0	67	2	16(21)
26-50	32	**33**	29	11	33	10	19(26)
51-100	21	0	**14**	22	0	11	14(19)
101-200	5	0	43	**33**	0	30	23(30)
201-300	0	17	0	22	**0**	6	5 (7)
Over 300	8	0	0	11	0	**41**	23(30)
Total %	29	5	10	7	2	47	100
(n)	(38)	(6)	(14)	(9)	(3)	(63)	(133)

[1]Missing observations due to heavy snow cover = 38.

[2]Actual distances were systematically measured and reported by observers, while reported distances came from user questionnaires. Cells representing accurate responses are in bold face.

[3]Percentage sums may not equal 100 due to rounding.

Table 2.--Accuracy of reported campsite distance from water[1, 2]

Self-reported distance	Actual distance in feet						
	0-25	26-50	51-100	101-200	201-300	Over 300	Total
Feet	Percent[3]						n
0-25	**44**	18	3	3	0	0	12(16)
26-50	32	**53**	21	3	14	0	19(26)
51-100	16	0	**58**	26	0	0	24(33)
101-200	8	18	18	**46**	29	41	27(38)
201-300	0	12	0	10	**14**	12	6 (9)
Over 300	0	0	0	13	43	**47**	12(16)
Total %	18	12	24	28	5	12.3	[3]100
(n)	(25)	(17)	(33)	(39)	(7)	(17)	(138)

[1]Missing observations due to heavy snow cover = 33.

[2]Actual distances were systematically measured and reported by observers, while reported distances came from user questionnaires. Cells representing accurate responses are in bold face.

[3]Percentage sums may not equal 100 due to rounding.

Respondents were somewhat more accurate in their estimated distance from a lake or stream (table 2). Forty-four percent of those individuals camping less than 25 feet from water were accurate in their reported measurement, while 56 percent reported 26 to 100 feet. Nearly one half (47 percent) of the respondents accurately reported their campsite distance from water at over 300 feet, while 41 percent estimated 101 to 200 feet. As with distance from trail, respondents tended to overestimate shorter distances and underestimate longer distances.

The chi-square test of significance was used to determine if there were differences in reported and observed behavior for the nominal variables. Ninety-six percent (N = 76) of the campers observed with wood fire also reported wood fire. The following results focus primarily on discrepant responses rather than accurate responses. Three individuals who reported using a stove only were also observed with a wood fire. Seven visitors who were observed using branches from live trees reported using only dead/down wood. Ten people who were observed using a new fire ring reported use of an existing ring. All visitors using a wood fire were observed with their fire made on top of the ground, but 17 people reported using a shallow pit for their fire. Ten people whose ashes were observed left in the fire ring reported they bury or scatter their campfire ashes. Eight of the visitors who were observed without a naturalized campfire reported that they always naturalize their campfire. Nineteen people left 1 to 10 pieces of unburnable trash in the fire ring or on the campsite and reported they pack out all unburnable trash. The seven visitors with horses were observed tying their stock to trees and all seven reported the same.

In order to investigate the possible relationship between self-reported accuracy and visitor characteristics, an accuracy score was developed for each individual. The accurate responses (observed) were compared to the self-reported responses (questionnaire), and a score was awarded the respondent. A perfect score of 10 points was based on an accurate response regarding the following behaviors: distance from trail, distance from water, type of fire, source of wood, use of fire ring, method of building fire, disposal of ashes, naturalization of fire ring, method of tying stock, and disposal of unburnable trash.

Those persons who did not use a wood fire could miss only 5 points on the accuracy scale; therefore, the scores were standardized to a 10 point scale. The mean score for accuracy was 6.9. Campsite distances from trail and water for early season visitors in the high alpine area could not be observed due to the snow cover; these early visitors usually did not have a wood fire due to the fire ban, and they could not travel by horse due to heavy snow. These 38 cases were not included in the accuracy score analyses, as their score was based only on the type of fire used and discarded unburnable trash.

Respondents were classified into groups on the basis of their accuracy score in order to determine relative frequencies. Three groups were established: high accuracy (score = 8-10, N = 40, 30 percent), moderate accuracy (score = 6-7, N = 66, 50 percent), and low accuracy (score = 1-5, N = 27, 20 percent). In addition, a score was developed to determine the impact of the somewhat strict measures of

distance from trail and water. A leeway accuracy score allows for one value discrepancy (underestimation or overestimation) regarding distance from trail and water, in which no point is subtracted. A t-test for the dependent sample showed that the original accuracy score and the leeway score were statistically different ($p \leq 0.001$). Given the leeway score, nearly one half (N = 63, 47 percent) of the visitors scored in the high accuracy range; 36 percent (N = 48) scored moderate accuracy, and 17 percent (N = 22) scored in the low accuracy range.

In order to investigate a possible relationship between accuracy scores and appropriateness of camping techniques, a visitor behavior score was established. One point was assigned to the visitor for each negative or inappropriate behavior, based on Forest Service recommendations for appropriate backcountry techniques in the Three Sisters and Mount Washington Wilderness areas. Behavior scores were based on the same behaviors included in the accuracy score and were weighted according to degree of inappropriateness. No significant relationship, as measured by the Pearson's Correlation, was found between accuracy scores and appropriateness of visitor camping techniques.

There is a positive correlation ($r = 0.20$, $p \leq 0.05$) between age and accuracy, indicating that older visitors tend to be more accurate in self-reporting backcountry behavior. Using analysis of variance (ANOVA) calculations, a significant difference ($p \leq 0.05$) among mean accuracy scores showed that visitors 8 to 19 years of age averaged 6.22 (N = 37); users 20 to 29 averaged 6.85 (N = 24); visitors 30 to 39 averaged 7.33 (N = 32), and users 40 and over averaged 7.41 (N = 25). Although the youngest category included 8 to 19 years of age, only one respondent was under 12 years old. Given one point leeway on the accuracy scale, mean scores remained significantly different.

A positive correlation ($r = 0.21$, $p \leq 0.01$) exists between education and accuracy. Those visitors with higher levels of education tend to respond more accurately than visitors with less education. A significant difference ($p \leq 0.05$) among mean accuracy scores showed that users with an eighth grade education or less averaged 5.30 (N = 19); those with 9 to 12 years of education averaged 7.40 (N = 27); visitors with some college or technical school averaged 7.41 (N = 14), and those with a college degree or some graduate college scored a mean of 7.19 (N = 67). Given one point leeway on the accuracy scale, mean scores remain significantly different.

Length of stay is negatively correlated with accuracy ($r = -0.14$, $p \leq 0.05$). This weak but significant correlation indicates that those visitors staying longest in the wilderness tend to be less accurate in their self-reported behavior.

No significant relationship, as measured by the Pearson's Correlation was found between income, party size, and accuracy scores. No significant differences were found among the mean accuracy scores as measured by ANOVA for the following nominal variables: visitor activity, method of travel, gender, occupation, and party composition.

DISCUSSION

In contradiction to the original hypothesis, it appears that most users are accurate in reporting discrete behaviors. For example, only three people were not accurate in reporting the type of fire they used. Response error was greater for estimating continuous measures on an interval scale. Measurement of campsite from trail and water was less accurate, with visitors tending to overestimate at the lower distances and underestimate at the greater distances. Response error decreased significantly when scores were evaluated by a leeway scale. This finding indicates that response error on estimated distances was linked to the given scale.

Investigation of the relationship between self-reported accuracy and selected visitor characteristics provided little explanation for the variance in visitor response error. There was no correlation between appropriateness of visitor behavior, visitor activity, and self-report accuracy. There was a low but significant correlation between age, education, and self-report accuracy. The younger, less-educated population tended to be less accurate in their responses. A very weak correlation existed between length of stay and accuracy, with the short-stay visitors responding most accurately.

Discrepancies between self-reported and actual behavior may have many explanations. For example, definitional problems may occur if a visitor is not familiar with terms such as naturalization or shallow pit fire. Such terms were explained with short phrases on the questionnaire; however, the visitors may have bypassed the explanations.

Another explanation for response error may be related to the issue of intentions versus behaviors. It was imperative to write the survey in present tense, due to the spuriousness of visitor situations at the time of data collection. Intrusion to the backcountry visitor seemed least offensive in the evening after camp was set up and supper finished, or late in the morning after breakfast. When people were packing up to leave, intrusions appeared to be less welcome. Visitors were explicitly instructed, both verbally and on the survey, to respond based on their present situation. However, there may have been a time lag between the survey responses and the visitor behaviors. For example, a visitor may have reported that he/she naturalizes their campfire before it was actually done; thus the response becomes one of intention rather than actual behavior. Another example is that of unburnable trash. Unless the visitor is fully packed and ready to hike, it is problematic to ask whether they pack out all

unburnable trash in the present situation. The response is one of intention until the point of departure. Frequencies reported for naturalization techniques and unburnable trash disposal should therefore be interpreted with caution. These limitations must be considered for future studies.

The most nonproblematic behavior questions, related to the intention versus behavior issue, were the measurement of distance from trail and water. The camper had already pitched the tent prior to the survey and the distances were easily measured following the visitor's departure. Interpretation of the responses are most problematic in terms of explaining the inaccuracy. It may be caused by an inability to estimate or a reluctance to admit (even to oneself) inapropriate behaviors. Based on the results of this study, one may expect that both elements were present given the overestimation of short distances and underestimation of long distances. Following the written self-report, 80 percent of the parties queried the investigator or other party members as to how far they were camped from water and trail. Thus, field observations of visitor conversations and reactions to reporting behaviors indicated that inaccuracy was seldom due to malicious or purposeful error, but rather to a combination of poor estimation, misinformation, and the age-old conflict between intentions and behaviors.

The study design precludes definitive statements about the representativeness of users or behavior over time and space (Hendee and others 1977). The results cannot be generalized for all wilderness areas because vegetation, topographical patterns, and user characteristics may all impact user behavior (Heberlein and Dunwiddie 1979). This study was exploratory and provides baseline data for comparing similar investigations.

Recommendations for future studies include testing additional indicators, such as visitor attitude and other social-psychological variables, for visitor accuracy. Different scale intervals from trails and water may be tested. Data should be gathered on site at the time of visitor departure to investigate problematic variables regarding intention versus behavior. This method, however, may be an unwelcome intrusion for the backcountry visitor. Furthermore, sampling at the time of departure would result in a small sample size, as users are dispersed and visitors leave their sites at unpredictable times. A team of observers would be necessary to acquire an adequate number of responses. Finally, researchers need to evaluate the issue of reactivity; that is the influence of the observer being on-site while the visitor responds to the survey. Wilderness researchers must further grapple with the issue of sampling ethics, as on-site surveys invade the solitude of backcountry visitors. Thus, the problematic nature of directly observing the wilderness visitor behavior deserves an indepth analysis.

The findings of this study have wilderness management implications for targeting education and information programs. Campsite distance estimates are problematic; therefore, education programs should include specific techniques on measuring campsite distance from trails and water. Young and less-educated visitors tend to be less accurate in reporting behavior; this may indicate a need for clarifying behavioral terms (such as naturalization of campfires). Efforts to educate in school and through youth organizations are supported by the findings of this study. Researchers, policy makers, and management personnel should be alert to possible discrepancies between what people do and what they say they do until there is further knowledge of the link between words and deeds of wilderness users.

REFERENCES

Campbell, Frederick L. Participant observation in outdoor recreation. Journal of Leisure Research. 2(4): 226-236; 1970.

Chase, David R.; Harada, Munehiko. Response error in self-reported recreation participation. Journal of Leisure Research. 16(4): 322-339; 1984.

Deutscher, Irwin. Words and deeds: social science and social policy. Social Problems. 13: 235-254, 1966.

Hancock, H. K. Recreation preference: its relation to user behavior. Journal of Forestry. 1973 June: 336-337.

Heberlein, Thomas A.; Dunwiddie, Peter. Systematic observation of use levels, campsite selection and visitor characteristics at a high mountain lake. Journal of Leisure Research. 11(4): 307-316; 1979.

Hendee, John C.; Clark, Roger N.; Dailey, Thomas E. Fishing and other recreation behavior at high-mountain lakes in Washington State. Research Paper PNW-304. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1977. 27 p.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Miscellaneous Publication 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Lee, Robert G. Alone with others: the paradox of privacy in wilderness. Leisure Sciences. 1(1): 3-19; 1977.

Lucas, Robert C.; Oltman, Jerry L. Survey sampling wilderness visitors. Journal of Leisure Research. 3(1): 28-43; 1971.

Robertson, Rachel D. An investigation of visitor behavior in wilderness areas. Iowa City, IA: University of Iowa; 1981. 174 p. Ph.D. dissertation.

Shelby, Bo; Colvin, Rick. Encounter measures in carrying capacity research: actual, reported, and diary contacts. Journal of Leisure Research. 14(4): 350-360; 1982.

Stankey, George H. A framework for social behavioral research-applied issues. In: Burch, William R. Jr., ed. Long distance trails. New Haven, CT: Yale University; 1979: 43-53.

CROWDING AND SPECIALIZATION:

A REEXAMINATION OF THE CROWDING MODEL

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ABSTRACT: The traditional crowding model suggests that perceptions of crowding are influenced not only by the number of contacts one experiences, but also by how the number of individuals encountered compares to one's expectations and preference for contacts. In this paper we hypothesize that the influence of these three variables on perceived crowding among hikers on the White Mountain National Forest in New Hampshire will vary according to hikers' level of specialization. Results confirmed that inexperienced and infrequent hikers, low specialists, depended more heavily than specialized hikers on contacts in evaluating crowding, although the evaluations of all hikers were influenced most by the degree to which contacts exceeded preferences. Expectations played no significant role in explaining crowding perceptions for hikers at any level of specialization. Preferences and contacts accounted for 47 percent of the variance in perceived crowding for highly specialized hikers, but only 29-30 percent for hikers in the lower levels of specialization.

INTRODUCTION

Efforts to understand the determinants of crowding perceptions in recreation settings have led to a large and diverse body of literature. Traditional models assumed that increases in visitor density levels and encounter levels were positively associated with crowding (Heberlein and Vaske 1977; Shelby 1980; Absher and Lee 1981; Bultena and others 1981). This research has generally found that while crowding perceptions are related to the number of other visitors encountered, individual expectations and preferences may be more important (Vaske and others 1982; Shelby and others 1983; Graefe and others 1984). Thus, recreationists report increased crowding not only as they come into contact with more visitors, but also when contacts exceed their expectations and preferences.

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Studies in the area of recreation specialization have also shown that individuals differ in terms of their experience, skill and current participation, and that these differences affect perceptions (Bryan 1979; Kauffman 1984). A recent study by Hammitt and others (1984) incorporated the two issues of crowding and specialization by examining the crowding model for a sample of inner tube floaters that the authors assumed to be nonspecialized participants. The relative influence of reported contacts on crowding was much greater, when compared to expectations and preferences, than had been typically found for more heterogeneous groups of users. Hammitt and others (1984) suggested that these findings might be due to less well-formed expectations and preferences of inexperienced or occasional users.

The purpose of this study is to expand the work of Hammitt and others (1984) by examining the influence of reported contacts, expectations, and preferences on crowding perceptions reported by individuals at different levels of specialization within a particular recreation activity--hiking.

RELATED RESEARCH

A number of authors have made the important distinction between density and crowding (Altman 1975; Stockdale 1978; Stokols 1972). Density refers to the number of individuals in a particular setting. Crowding occurs only when a particular density is evaluated as too high. The research completed to date has repeatedly demonstrated that individuals vary in their response to intensive recreational use (Graefe and others 1984). Although a variety of explanations have been offered to account for these differences, two variables are prominent in the literature--expectations and preferences.

Expectations refer to specific beliefs about the number of other individuals to be encountered in a specific setting. For example, individuals expect certain outcomes based on their own personal experiences (Vaske and others 1980) or on information provided by others (Lime and Lucas 1977; Krumpe 1979). Preferences are more general beliefs about desirable or ideal conditions. Such preferences may be similar to expectations, but they can differ as well. One can expect to see large numbers of others hiking a trail during a weekend, but still prefer solitude.

A recent paper by Shelby and others (1983) examined the influence of contacts, preferences,

and expectations on crowding perceptions reported by recreationists in six different settings. In every case, regression models including all three independent variables had a significant effect on crowding. Adding expectations and preferences increased the amount of explained variance by an average of 9.6 percent over and above that accounted for by the contacts variable. For example, the addition of these two variables increased the explained variance from 22 percent to 33 percent for Wisconsin deer hunters, from 2 to 10 percent for Grand Canyon floaters, and from 2 to 21 percent for Rogue River, Oregon, rafters.

The data reported by Shelby and his associates revealed considerable support for the role of expectations. Seeing more recreationists than expected consistently resulted in people feeling more crowded. The strength of the effect, however, varied across settings. Among Rogue River floaters, Wisconsin deer hunters, and goose hunters at Grand River Marsh, Wisconson, expectations had the strongest effect of the three independent variables. At the Grand Canyon, expectations had considerably less effect than the preference measure, presumably because most of the respondents (90 percent) were first-time visitors and lacked the experience and information to develop realistic expectations. In the other data sets reported by Shelby and others (1983), preference had a smaller effect on crowding than expectations.

Such differences in expectations and preferences may exist among participants engaged in the same activity in a given environment, as well as people participating in different activities or areas. For example, studies examining conflicts between individuals engaged in backcountry camping suggest that most individuals prefer to camp away from others (Lucas 1964; Stankey 1973; Lee 1975; Badger 1975). A paper by Heberlein and Dunwiddie (1979), however, indicated that less-experienced individuals tended to select campsites close to other visitors, while those judged to be knowledgeable about camping chose locations farther away from the nearest visible campsite. Evidently, the experienced camper used a different set of behavioral standards to identify an appropriate site. The novice may not have been aware of this norm and inadvertently became a source of conflict by violating the standard.

The conclusions drawn from the Heberlein and Dunwiddie study reinforce the efforts of other researchers to differentiate recreationists into more homogeneous subgroups. Such classifications are based on the recognition that different individuals seek different experiences even within a single activity. Bryan (1979), for example, proposed a conceptual typology that arranged recreationists along a continuum reflecting their experience with and commitment to a given activity. The typology ranged from the beginning recreationist to the specialist. Individuals at each level of specialization were suggested to have distinctly different expectations and preferences.

As noted earlier, Hammitt and others (1984) provided one of the first attempts to directly link crowding perceptions with the concept of specialization. Their findings suggested that for nonspecialized recreationists, expectatons and preferences for encounters explained less variance in crowding than the reported rate of interaction. The argument and data reported by Hammitt and his associates are consistent with the specialization concept.

The study reported here extends the work of Shelby and others (1983) and Hammitt and others (1984) by examining the contribution of reported contacts, expectations, and preferences to crowding perceptions reported by individuals at three levels of specialization within a given recreation activity. We hypothesize that hikers who are inexperienced and participate infrequently (low specialists) will lack well-defined expectations and preferences for meeting others while hiking and, therefore, will depend more heavily on contacts in evaluating crowding in a wilderness setting. Highly specialized individuals, on the other hand, will have a clearer idea of how many other hikers they expect and prefer to see, and their perceptions of crowding will be influenced to a greater extent by these variables than by the number of people encountered. It is suggested, therefore, that the relative importance of each of the three predictor variables will differ depending on the hiker's level of specialization, and also that the degree of prediction of crowding from the three predictor variables will increase as level of specialization increases.

METHODOLOGY

Data for this study were collected through a survey of White Mountain National Forest (WMNF) hikers in the summer of 1982. Interviews were conducted (n = 334) on both heavily used and lightly used trails in designated wilderness and adjacent backcountry areas. Interview sites were determined through personal observations of hiker travel patterns and discussions with U.S. Forest Service and Appalachian Mountain Club personnel. Three groups of interviewers were assigned to hike through various sections of the Presidential Unit of the WMNF. When hikers were encountered along the trail, they were asked to complete a short self-administered questionnaire.

The survey was designed to examine a number of important issues related to backcountry hiking. Of significance to this paper were three variables used to determine level of hiker specialization and four variables that comprised the basic crowding model. Similar to previous studies (Kauffman 1984), the hikers were divided into high, medium, and low specialization groups using a composite index composed of the number of years of hiking experience, number of times hiking per year, and self-reported skill level (ranging from beginner to expert). The dependent variable in the crowding models was perceived crowding during the day's hike, measured on a 9-point scale ranging from "not at all crowded" to "extremely

crowded." The independent variables included number of reported contacts, expectations for contacts, and preferences for meeting others. Reported contacts were measured by asking hikers about how many other hikers they remembered seeing on the trail that day, not including the people in their own hiking party. Expectations and preferences were measured in two ways: first by directly asking respondents how many hikers they expected and preferred to see while hiking in the area, and also by asking individuals whether they had seen more, about the same, or fewer hikers than they had expected and preferred to see, respectively. The latter comparative evaluations by respondents were used in the crowding models based on previous research showing that respondent-defined judgments are more meaningful than statistically computed comparisons in predicting recreationists' perceptions (Vaske and others 1983).

RESULTS

Responses to the three variables used to construct the specialization index are shown in table 1. Individuals rated their hiking skills as either beginner (15 percent), intermediate (59 percent), or expert (26 percent). The three specialization categories for the remaining two variables were derived from open-ended responses and based on intuitive break points. Low specialization for the hiking experience variable ranged from 0 to 5 years of participation and included 31 percent of the sample. A similar percentage of respondents were included at the high end of the experience continuum (13 or more years of experience), while the remaining 37 percent were classified into the middle group. Relative to the number of hiking trips per year, 28 percent of the respondents indicated that they rarely hike (0 to 1 trips per year--low specialists), and two-fifths averaged two to four trips per year (medium specialists). Individuals in the high specialization group (32 percent) reported five or more hiking trips annually.

To create the specialization index, the scores (table 1) from each of the variables were summed, resulting in values ranging from 3 to 9. The specialization index score was then condensed into three categories, with scores of 3-4 indicating low specialization, 5-7 representing medium specialization, and 8-9 signalling high specialization. Under the scoring scheme, hikers could be assigned to the low level of specialization only if they scored the lowest level for at least two of the three scale variables. Similarly, high specialists included only those with high values for two or all three scale items. Using these criteria, nearly three-fifths (59 percent) of the respondents were classified in the middle category, while 18 percent were judged to be nonspecialists and 23 percent were considered highly specialized.

Table 2 details the hikers' reports of encounters with other hikers and their evaluations of these meetings. Overall, visitors reported an average of 15 hiker contacts (s.d. = 14.9). Although there were no statistically significant differences in the number of other hikers members of each group saw during their trips, evaluations of these meetings did vary significantly across levels of specialization. While crowding scores for all three groups were skewed towards the not crowded end of the scale, individuals in the high specialization category felt significantly more crowded than less specialized individuals.

Table 1.--Specialization scale item composition

Variable	Values in Scale	Number in Sample	Percent of Sample
Perceived hiking skill			
Beginner	1	50	15
Intermediate	2	198	59
Expert	3	86	26
Years of prior hiking experience			
0 to 5 years	1	105	31
6 to 12 years	2	123	37
13 or more years	3	106	32
Number of hiking trips per year			
0 to 1 trip	1	95	28
2 to 4 trips	2	134	40
5 or more trips	3	105	32
Specialization scale			
Low	3-4	60	18
Medium	5-7	198	59
High	8-9	76	23

Similar differences were noted for the preference variable. Individuals at the high end of the continuum were more likely than the least specialized group to indicate that they prefer to see fewer people than they actually encountered. Examination of the preferred number of contacts reported by each of these two groups supports these findings. The least specialized hikers preferred to see an average of 8.2 contacts, while the most specialized preferred a mean of 6.2 encounters.

Comparisons among the three groups on the expectation variable, however, did not reveal any significant differences. Each category of specialists tended to report seeing about the same number of others as expected. Analysis of the actual number of recreationists the hikers expected to see indicated that all three groups anticipated seeing an average of 19 other people. Taken together, these findings suggest that although those in the highest specialization group prefer fewer contacts, they have come to expect higher levels of encounters in the White Mountains.

Multiple regression was used to examine the effects of the three predictor variables on perceived crowding (table 3). Four separate

regression models were tested: one for the entire sample, and a separate equation for each specialization subgroup of hikers. As predicted, reported contacts did have a greater influence on crowding for individuals who were least specialized than for individuals who were in the highest level on the specialization scale. Further, the contribution of preferences for contacts was strongest for those who were highly specialized, although preferences for wilderness contacts was the most important factor affecting the perception of crowding in all of the equations. Expectations did not have a significant effect in any of the regression models. The two significant variables--contacts and preferences--explained 29-30 percent of the variance in perceived crowding for low and medium specialist hikers. In contrast, nearly half of the variance in crowding (47 percent) was explained for the highly specialized group. When the sample was analyzed as a single group, contacts and preferences accounted for 34 percent of the variance.

DISCUSSION

The data reported here reveal several similarities and differences with respect to other investigations of the basic crowding model. Consistent with earlier studies (Heberlein and Vaske 1977; Absher and Lee 1981; Bultena and others 1981; Vaske and others 1982; Shelby and others 1983; Hammitt and others 1984), our findings indicated that people feel crowded not only when they encounter more recreationists, but also when contacts exceed their preferences for interaction. In addition, the finding that more specialized individuals preferred fewer contacts and were more sensitive to crowding is consistent with the specialization concept and previous research (Bryan 1979; Vaske and others 1980).

Among the regression models tested in this paper, preferences were consistently the strongest predictors of perceived crowding. Compared to the Shelby and others (1983) and Vaske and others (1982) articles that analyzed a total of seven different data sets using the same model as the one examined here, the effect of preferences for this sample was considerably stronger and more uniform. In two of the data sets (Rogue River floaters and goose hunters at the Grand River Marsh managed hunt), for example, there was no effect of preferences on perceived crowding once contacts and expectations were controlled. For canoers on the Bois Brule River, Wisconsin, and two groups of hunters in Wisconsin (deer hunters and goose hunters on a "firing line"), the preference measure was the last variable to enter the equation. Preferences ranked second in importance among the three predictors for Dolly

Table 2.--Hiker-reported contacts and evaluations of visitor numbers by level of specialization

Dependent variables	Level of specialization[1] Low	Medium	High	F-Value
Contacts	15.82	13.68	18.12	n.s.
Crowding[2]	2.02[a]	2.57[a]	3.39[b]	8.66[3]
Preferences[4]	1.80[a]	1.68[ab]	1.53[b]	4.17[3]
Expectations[5]	1.85	1.84	1.88	n.s.

[1]Row means with similar superscripts do not differ significantly at the 0.05 level.

[2]Variable coded on a nine-point scale ranging from (1) "not at all crowded" to (9) "extremely crowded."

[3]$p < 0.05$

[4]Variable coded on three-point scale: (1) "I prefer to see fewer people," (2) "About the same," or (3) "I prefer to see more people."

[5]Variable coded on three-point scale: (1) "fewer than expected," (2) "about the same," or (3) "more than expected."

Table 3.--Effect of contacts, preferences and expectations on perceived crowding[1]

Independent variables	Dependent variable: perceived crowding[2] — Level of specialization: Low	Medium	High	Entire Sample
Contacts	.29[5]	.24[5]	.18[6]	.23[5]
Preferences[3]	-.35[5]	-.35[5]	-.58[5]	-.42[5]
Expectations[4]	.03	.10	.07	.07
R^2	.30	.29	.47	.34

[1]Cell entries are standardized regression coefficients.

[2]Variable coded on a nine-point scale ranging from (1) "not at all crowded" to (9) "extremely crowded."

[3]Variable coded on three-point scale: (1) "I prefer to see fewer people," (2) "About the same," or (3) "I prefer to see more people."

[4]Variable coded on three-point scale: (1) "fewer than expected," (2) "about the same," or (3) "more than expected."

[5]$p < 0.01$

[6]$p < .05$

Sods, West Virginia, hikers, and at the Grand Canyon, preferences had the strongest influence on crowding perceptions.

Expectations, on the other hand, had no significant impact on crowding in any of the regression models examined here, in contrast to previous studies that have consistently found perceived crowding to be dependent upon the degree to which encounter levels matched the number of contacts expected (Heberlein and Vaske 1977; Absher and Lee 1981; Bultena 1981; Vaske and others 1992; Shelby and others 1983; Hammitt and others 1984). The apparent reversal in the roles of preferences and expectations in the current study may be a function of the particular circumstances found in the White Mountain National Forest. Perhaps expectations played no significant role because most respondents reported seeing about the same number or fewer people than they expected to see. Contact preferences, on the other hand, were exceeded for the majority of hikers and therefore had a greater influence on the perception of crowding. It seems plausible that the relative influence of expectations and preferences in a given situation depends on the interrelationships between both variables and the actual number of other visitors encountered.

Another perspective for evaluating our findings against those of others is in terms of the overall amount of explained variance. The model for the entire sample of White Mountain hikers accounted for 34 percent of the variance in perceived crowding. This finding equals or exceeds the explained variance estimates found by Shelby and others (1973) or Vaske and others (1982). Some researchers (Heberlein and Vaske 1977; Hammitt and others 1984) have reported higher R^2 values; however, these studies included other variables in addition to those examined here.

The major objective of this study was to examine the crowding model relative to distinct levels of specialization within a single activity. Contrary to the findings reported by Hammitt and others (1984), and our hypotheses, which suggested that contacts would be the strongest predictor of crowding for nonspecialists, the preference variable was the strongest predictor of perceived crowding in all of the equations examined. The degree of prediction of crowding, however, as anticipated, was greater for the highly specialized group ($R^2 = 0.47$) than for the other two categories of hikers ($R^2 = 0.30$, low specialization; $R^2 = 0.29$, medium specialization). It is also interesting to note that the equation for the specialized group explained 13 percent more of the variance than the model for the entire group (47 percent versus 34 percent), further suggesting the need to differentiate users into more homogeneous subgroups.

Although these results fail to fully confirm the predicted relationships, the findings may be partially explained by the observed distribution of the specialization index. Only 23 percent of the hikers ($n = 76$) were classified as specialists and even fewer (18 percent, $n = 60$) were categorized as nonspecialists. Perhaps different results would be obtained under some alternate group boundaries or method of classification. Another explanation concerns the variables used to define the specialization scale. The three measures included in this paper were consistent with previous specialization studies (Bryan 1979; Kauffman 1984); however, they may not provide a comprehensive measure of specialization. Future research utilizing larger sample sizes and alternative strategies for determining specialization should help to resolve these issues.

In summary, this paper has begun the process of examining traditional crowding models relative to different groups of individuals practicing a specific recreation activity in a particular setting. Wilderness managers might use this kind of information in deciding whether use limits or less restrictive management techniques such as information dissemination are appropriate. A somewhat related application involves using data on visitor preferences and expectations to designate specific areas for individuals with similar backgrounds who desire particular kinds of experiences. This rationale is similar to trout management strategies that restrict usage of certain streams to fly fishermen. Additional research is needed, however, to further document differences that influence perceptions of the wilderness experience.

REFERENCES

Absher, J. D., Lee, R. G. Density as an incomplete cause of crowding in backcountry settings. Leisure Sciences. 4(3): 231-247; 1981.

Altman, I. The environment and social behavior. Monterey, CA: Brooks/Cole; 1975. 256 p.

Badger, T. J. Rawah Wilderness crowding tolerances and some management techniques: an aspect of social carrying capacity. Fort Collins, CO: Colorado State University; 1975. 83 p. M.S. thesis.

Bryan, H. Conflict in the great outdoors: toward understanding and managing for diverse user preferences. Sociological Studies No. 4. Tuscaloosa, AL: University of Alabama, Bureau of Public Administration; 1979. 99 p.

Bultena, G. L.; Albrecht, D.; Womble, P. Freedom versus control: a study of backpackers' preferences for wilderness management. Leisure Sciences. 4(3): 297-310; 1981.

Graefe, A. R.; Vaske, J. J.; Kuss, F. R. Social carrying capacity: an integration and synthesis of twenty years of research. Leisure Sciences. 6(4): 395-431; 1984.

Hammitt, W. E.; McDonald, C. D.; Noe, F. P. Use level and encounters: important variables of perceived crowding among non-specialized recreationists. Journal of Leisure Research. 16(1): 1-8; 1984.

Heberlein, T. A.; Dunwiddie, P. Systematic observation of use levels, campsite selection and visitor characteristics at a high mountain lake. Journal of Leisure Research. 11(4): 307-316; 1979.

Heberlein, T. A.; Vaske, J. J. Crowding and visitor conflict on the Bois Brule River. Technical Report WIS WRC 77-04. Madison, WI: University of Wisconsin, Water Resources Center; 1977. 109 p.

Kauffman, R. B. The relationship between activity specialization and resource related attitudes and expected rewards for canoeists. College Park, MD: University of Maryland; 1984. 133 p. Dissertation.

Krumpe, E. E. Redistributing backcountry use by a behaviorally based communications device. Fort Collins, CO: Colorado State University; 1979. 156 p. Dissertation.

Lee, R. G. The management of human components in the Yosemite National Park Ecosystem. Yosemite, CA: The Yosemite Institute; 1975. 134 p.

Lime, D. W.; Lucas, R. Good information improves the wilderness experience. Naturalist. 1977 Winter: 18-20.

Lucas, R. C. The recreational capacity of the Quetico-Superior area. Research Paper LS-15. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station; 1964. 34 p.

Shelby, B. Crowding models for backcountry recreation. Land Economics. 56(1): 43-55; 1980.

Shelby, B.; Heberlein, T. A.; Vaske, J. J.; Alfano, G. Expectations, preferences and feeling crowding in recreation activities. Leisure Sciences. 6(1): 1-14; 1983.

Stankey, G. H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-142. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 61 p.

Stockdale, J. E. Crowding: determinants and effects. Advances in Experimental Social Psychology. 11: 197-247; 1978.

Stokols, D. On the distinction between density and crowding: some implications for future research. Psychological Review. 79: 275-277; 1972.

Vaske, J. J.; Donnelly, M. P.; Heberlein, T. A. Perceptions of crowding and resource quality by early and more recent visitors. Leisure Sciences. 3(4): 367-381; 1980.

Vaske, J. J.; Donnelly, M. P.; and Tweed, D. L. Recreationist-defined versus researcher-defined similarity judgments in substitutability research. Journal of Leisure Research. 15(3): 251-262; 1983.

Vaske, J. J.; Graefe, A. R.; Dempster, A. B. Social and environmental influences on perceived crowding. In: Wilderness Psychology Group: Proceedings; 1982, July 8-9; Morgantown, WV: West Virginia University; 1982; 211-227.

RECREATION SPECIALIZATION AS A FACTOR IN BACKCOUNTRY TRAIL CHOICE

Daniel R. Williams and Michael G. Huffman

ABSTRACT: Trail information was provided to recreationists in Rocky Mountain National Park in an effort to redistribute backcountry use. Backcountry recreation specialists used the information as often as novices. Specialists sought out more sources of information about trails and indicated a preference for more challenging trails. Use of the recreation specialization concept may not be appropriate for analyzing broad categories such as backpackers. Its usefulness in examining the effectiveness of redistribution efforts across subgroups in this study was limited.

INTRODUCTION

In 1983, the National Parks recorded over 2.5 million overnight backcountry visits compared to 2.6 million in 1976 (U.S. Department of the Interior 1984). Growth in wilderness recreation appears to have stabilized for the present, but concerns about high levels of wilderness use remain (Cordell and Hendee 1982). Managers will continue to be challenged to protect the wilderness resources while at the same time provide large numbers of visitors with opportunities for quality wilderness experiences.

While overall use levels remain high, much use is concentrated on a relatively small portion of the total wilderness resource. Among the many strategies available to wilderness managers to reduce visitor impacts is to redistribute use more evenly across space and time. Perhaps the most widely advocated methods are those that disseminate trail information to potential wilderness users. The information usually describes lesser used trails in an effort to change visitors' trail selections (Krumpe 1979; Manning and others 1981). An informational approach has the advantage that it is nonauthoritarian and can actually serve visitors' desires rather than restrict and regulate them. Providing information that reflects visitors' needs in making wilderness trail decisions has proven particularly effective (Krumpe 1979; Huffman and Williams, this proceedings).

Bryan (1977) introduced the notion of recreation specialization as a means of understanding differences in attitudes and behavior patterns of participants in an outdoor activity. The purpose of this study is to report on the usefulness of the specialization concept for examining the relative effectiveness of trail use redistribution efforts across subgroups of backcountry users. To date recreation specialization has not been applied to backpacking or wilderness use; however, application of the concept to canoeing (Wellman and others 1982) and fishing (Bryan 1979; Graefe 1981) suggests it has potential as a way to understand the diversity of wilderness behavior.

Specialization has been used to explain differences in conservation attitudes (Katz 1981), expected rewards (Kauffman and Graefe 1984), and norms of "depreciative" behavior (Wellman and others 1982). Williams (1985) suggested that specialization may be important to understanding how recreation participants make decisions and process information about recreation opportunities. Several decision models have been used in the design of information systems aimed at redistributing wilderness use. The usefulness of any one model depends on the decision context (the set of alternatives to choose from) and the background of the decision maker. Specialization may hold promise as a way to characterize the background of the decision maker.

RECREATION SPECIALIZATION

Specialization as defined by Bryan (1977:175) "...refers to a continuum of behavior from the general to the particular, reflected by equipment and skills used in the sport and activity setting preferences." Thus, recreationists begin at one end of the continuum with a more or less general interest in an activity and progress through participation to a point where their interests are limited to some special branch of the activity. For trout fishermen, Bryan described the continuum as ranging from "occasional fishermen," novices for whom fishing is not a regular leisure activity, to "technique-setting specialists," who are deeply involved in their sport and tend to concentrate on one approach (fly fishing) in one setting (spring-fed trout streams).

Recreation specialization, as a way to classify forms of an activity, specifies the frame of reference from which a participant evaluates alternative behaviors. Bryan notes that within-sport variability has not been adequately studied, particularly with regard to the treatment of the underlying processes accounting for the variability. Through informal interviews, Bryan collected information on four aspects of fishing participation: (1) orientation to fish (number, size, type of fish), (2) orientation toward the resource (the setting of the fishing experience), (3) history of interest and activity in the sport, and (4), the

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relationship between the leisure activity and other areas of life. Bryan found support for the idea of fishing careers that evolve from occasional fishing to committed angling.

An important dimension in Bryan's scheme of specialization is resource orientation. Specialization is thought to be at least partially reflected by setting preferences in addition to equipment and skill of the participant. Bryan's view is that the specialist becomes resource specific (a preference for alpine trout streams only versus any body of water with abundant fish). Some have gone so far as to suggest that settings take on a symbolic significance beyond functional considerations of how suitable a setting is for carrying out the activity (Williams 1980; Tuan 1977). A specialized resource orientation is likely to affect the trail selection process.

Bryan interprets the specialization process as driven by "social world" reference groups (Shibutani 1955) that come into existence with the development of specialized channels of communication. Over the course of a lifetime of participation in an activity (leisure career), a recreationist acquires from other highly committed participants a set of meanings, preferences, and norms of behavior that guide his participation patterns. These values are transferred via the "leisure social world" associated with the activity. The most highly involved and committed participants make up the leisure social world, those who set the standards for attitudes and behaviors related to the activity. Through such media as guide books, specialty magazines, equipment catalogs, and other providers of symbols, members impart a cultural definition of the activity to the less specialized participants. With advancement, the novice participant increasingly assimilates the "specialized" world view. For example, in Bryan's study those low in specialization were found to view the activity of fishing as secondary to the social context of the outing. For specialized anglers, the primary purpose was restricted to the fishing activity itself, which was often engaged in with peers sharing common interests and skill (Bryan 1977).

In this study specialists were hypothesized to process information differently in selecting a trail. Redistribution of trail use was hypothesized to be less effective for specialists than nonspecialists because specialists would more likely have formulated resource preferences and therefore be less willing to be persuaded. Further, it was hypothesized that specialists would give less weight to constraining factors (time, knowledge, skills, and so forth) in making a site selection. These hypotheses were tested using data collected in Rocky Mountain National Park as part of a field experiment designed to redistribute backcountry use to less impacted areas.

METHODS

Bryan's research has been confined to trout fisherman, although he offered sample specialization sequences for a number of outdoor pursuits, including backpacking. For backpacking he proposed a continuum from day-hike/overnighters to on-trail distance backpackers, to off-trail backpackers. Our purpose was not to provide descriptive labels for the specialized forms but to develop an index of backpacking specialization following the approach Wellman and others (1982) took in a study of Virginia canoeists. They attempted to measure specialization using a questionnaire to create an index of specialization. Specialization was measured through questions on the respondent's canoeing experience; equipment ownership; linkage to other canoeists through organizations, books, or periodicals; equipment making; canoeing-related expenditures; and a series of self-descriptions of the role of canoeing in the person's life.

Experimental Design

The present study is based on data collected as part of a field experiment conducted in Rocky Mountain National Park during a 3-week period from August 20 to September 15, 1984. Approximately 90 percent of the backpackers using the Park receive their permits from Estes Park; therefore, the study was conducted at that contact station. Since generalization to the large population of backpackers in the Park was not of primary importance, no attempt was made to sample the population.

Backpackers seeking permits for Rocky Mountain National Park were randomly assigned to one of three experimental treatments: a control group that filled out the permit in the usual way, and two treatment groups that received trail information designed to encourage selection of 29 lesser used trails in the Park. The two treatment groups differed in the way the information was given, but for the purpose of the present analysis data from those receiving either information treatment were used. For the treatment groups, instructions were given to examine the information before completing the permit application form that indicated their backcountry site choice. Choices were coded to indicate whether they selected a site that was included in the information treatment. After the permit was completed, subjects were told they were part of an experiment and asked to complete at their convenience a mail-back questionnaire. A total of 159 subjects were included as part of the experiment. Of these, 156 agreed to fill out a questionnaire. After one follow up mailing, 146 were returned for a 92 percent response rate. Nonresponse checks were not considered necessary.

Questionnaire Design

For the purposes of this study, specialization was measured following the example of Wellman and others (1982). It should be noted that the measurement methods used in the past and the present study are not yet refined enough to validate Bryan's theoretical perspective on specialization. Rather, indices of specialization have been constructed based on indicators of amount of participation in the activity, evidence of involvement in the activity as a central life interest, and commitment as evidenced by expenditures on equipment and for participation. Participation was measured by total backpacking trips

outside Rocky Mountain National Park, number of days backpacking in 1984, and number of days climbing in 1984. Involvement was measured through questions regarding membership in outdoor and conservation organizations, subscriptions to and ownership of outdoor literature, political activity in conservation issues, and equipment ownership. Equipment ownership was measured by a 21-item checklist and an overall estimate of investment in equipment. The list included both backpacking (16 items) and climbing (5 items) equipment with scores given for number of items in each category.

In addition to specialization items described above, subjects were asked about previous experience backpacking in Rocky Mountain National Park, background characteristics (age, sex, education level, group size, trip length, community size), whether they used the information in making a decision, whether they had a trail in mind before arriving at the Park, sources of information they consulted about trails in the Park, and ratings of 20 trail-attribute preferences. Further, subjects were asked to rate the quality of the information.

RESULTS

Index of Specialization

A total of 13 variables were examined in creating an index of backpacking specialization. From a factor analysis, 10 variables were retained and organized into three general categories: backpacking experience (four variables), climbing experience (two variables), and involvement (four variables. Through analysis of item-total correlations for each group, all variables were retained to form three subscales to specialization. The standardization of the variables to be used in the index of specialization was accomplished by dividing each subject's score for each variable by the standard deviation for each variable. The final index of specialization was computed by adding the standardized scores for all 10 variables. Internal consistencies and intercorrelations for subscales and the overall index of specialization are presented in table 1. Specialization index scores averaged 16.36 with a standard deviation of 4.93.

The level of specialization was compared to background characteristics. Level of specialization was not found to vary with backcountry group size, community, sex, age, and length of trip. Specialization was positively correlated with level of education, $F(3,142) = 5.97$ ($p < 0.001$). Roggenbuck and others (1980) found specialization positively associated with age, education, and being male, noting that most differences appeared to be related to age. Further, specialization levels did not vary with amount of previous backcountry experience in the Park. This may be due in part to a lack of variance in park experience (standard deviation = 1.3). All subjects in the experiment indicated at least one previous backcountry trip in the Park.

Differences were also observed on specialization by treatment, $F(2,143) =$ ($p < 0.03$). The control group tended to be more specialized than either treatment group and significantly different than the brochure group. Given the random assignment to treatment, the treatment "effect" may be normal statistical variation or nonresponse bias (seven of the 13 nonrespondents were from the control group--14 percent of the control subjects). If nonrespondents in the control group were less specialized than subjects, a treatment effect might be observed.

A third possibility is a treatment effect on questionnaire responses. A similar treatment effect was noted in other questionnaire items and may have to do with insufficient justification for being influenced by the treatment. If a subject finds himself influenced by the information, already having made an earlier decision about a trail, the subject may have a tendency to rationalize his choice of a different "recommended" trail by not rating himself as a specialized backpacker.

The effect of specialization on decision making was analyzed in several ways: use of a site recommended by the information treatment, reported use of the information, number of information sources consulted about backcountry opportunties, whether a choice had been made prior to seeking a permit, and trail attribute preferences.

The major hypothesis that those making a recommended choice and reporting that the information was used would be less specialized was not confirmed (table 2).

Table 1.--Cronbach's alpha and intercorrelations for subscales and specialization index

Scale	Cronbach's alpha	Scale: Backpacking	Climbing	Involvement	Specialization
Backpacking	0.59	1.00			
Climbing	.63	.25	1.00		
Involvement	.57	-.03	.23	1.00	
Specialization	.60	.51	.73	.66	1.00

Those who reported using the trail information in selecting their site were neither more or less specialized ($F[1,94] = 0.29$). As another test, specialization level was compared between those who selected designated trails and those who did not. Again no relationship was found ($F[1,98] = 0.14$). However, comparing those with more backcountry experience in the Park with use of the information in trail selection showed that those with only one previous visit were more likely to use the decision aid than those with two or more previous visits (table 3).

Table 2.--Mean score on specialization index by use of information and use of designated trail

Response	Mean specialization score	
	Use of information	Use of designated trail
Yes	15.9	15.8
No	15.4	15.4
Overall mean	15.7	15.6

Table 3.--Use of information by amount of park experience

Experience	Used		Not used	
	N	%	N	%
One visit	38	76	23	47
Two or more visits	12	24	26	53
TOTAL	50	100%	49	100%

Chi-square = 7.65, 1 d.f. $p<0.001$
Sommer's D = -0.31

While the hypothesis was not confirmed, specialization was positively related to the number of information sources consulted (friends, writing to the Park, trail guide, and so forth), but not related to whether a prior decision on backcountry opportunities had been made. Specialists apparently had accessed more information prior to arriving at Rocky Mountain National Park, but were not more likely to have formulated a decision prior to arriving. Specialists were more likely to search for information, but were not different from nonspecialists in their use of the trail information.

The second major hypothesis was that specialists would use different information in arriving at a choice. While this was not tested directly it was felt that the type of information as indicated by trail attribute preferences would vary with specialization. As mentioned earlier, each respondent was asked to evaluate the importance of 20 trail attributes on a 4-point scale of preference from very important to not important. These responses were factor-analyzed (PA2; Nile and others 1975).

From a plot of eigenvalues by factors, three factors were indicated by a clear bend or elbow in the curve. Two factors were retained. The first factor labeled facilitators, the second constraints following the pattern suggested by Krumpe and McLaughlin's (1982) model of decision making (table 4). The first factor contained items indicating preferences for trails leading to the high country, trails that go above timberline, trails where I could climb a mountain peak, trails with views of mountains, and long trails--staying at new areas each night. The second factor contained items indicating preferences for well-marked trails, easily accessible trailheads, trails without risk or danger, and trails where other people would be seen. These items are most likely to be processed as constraints; that is, a minimum threshold on these attributes must be present for an alternative to be given consideration. As expected specialization was positively correlated with the facilitator factor ($r = 0.20$; $p<0.01$) and negatively correlated with the constraint factor ($r = -0.37$; $p<0.001$).

Table 4.--Factor analysis of trail attribute preferences using iterative principal factoring and quartermax rotation

Variable	Factor 1	Factor 2
Takes me above timberline	0.85	-0.12
Climb to the top of mountain peaks	.77	- .14
Leading to high country	.58	- .13
Camp in a new area every night	.46	.00
Views of mountain peaks	.31	.16
Well-marked trails	- .08	.81
Without much risk or danger	- .12	.59
Trailhead that was easily accessible	- .06	.57
Where several others would be seen	.09	.33

DISCUSSION

The findings with respect to our hypotheses are mixed. Specialization was not lower as hypothesized for those who claimed to use the trail information in making a trail selection. If anything there was a slight tendency for specialization to be higher among those who used the information. However, more specialized participants tended to seek out more information from other sources. Further, the behavior of experienced Rocky Mountain National Park backcountry users was similar to what we hypothesized for specialists. Experienced visitors were less likely to use the trail information. While it appears experience may have a bearing on choice, that experience must be directly related to the Park and not the general experience that comes with specialization. Specialization alone was not enough to ensure that the visitors arrived with a choice in mind, only that they had done their homework.

The findings related to the types of trail attributes preferred by specialists were more consistent with our hypotheses. High specialization was associated with a high preference for facilitating attributes and a low preference for constraints. Given their greater skill, knowledge, and equipment, specialists are more likely to base a decision on facilitators because the minimum thresolds of constraints are low or nonexistent. We did find that constraints related to time available did not fall clearly in one of the two factors. This may be because time constraints apply to all regardless of specialization level.

These findings indicate that even specialized participants benefit from attempts to provide onsite information about backcountry opportunities. Decision-making styles are likely to be different for specialized participants. Some of the controversy over different decision models may be related to the frame of reference of the decision maker. Given their propensity to seek out more information, specialists are likely to base decisions on facilitators and use a maximizing (compensatory) method of weighting alternatives. Nonspecialists who have little information or knowledge of what to seek out or how to weigh the attributes may be more likely to use a constraint-driven approach that focuses on minimum thresholds rather than on maximizing facilitators.

While specialization research represents an important contribution, a major limitation of this approach has been that the degree of specialization is defined relative to a particular recreation activity rather than the degree of specialization in outdoor recreation generally. As others have argued (Driver and Tocher 1970), activity definitions of recreation engagements alone are vague and ambiguous; it is often difficult to draw boundaries between one activity and another. With measurement focused on involvement in a specific activity, people who are low on backpacking specialization, for example, may still be highly specialized with respect to some other activity (canoeing for example) that carries over to backpacking in terms of environmental preferences (desire to see few people). Further, in the process of specialization one may advance from one sport to another (for example, hiking to rock climbing). Consequently, finding attitudinal differences in specialization may be confounded somewhat by activity-specific measurement.

This may account for the problems observed in the study by Wellman and others (1982). No relationship between specialization and environmental attitudes was found, possibly because those classified as nonspecialists in canoeing were specialists nonetheless, specialists in a different activity that did not show up in the activity-specific measurement. Yet, the process of becoming involved in a pursuit may lead to similar consequences regardless of which activity one participated in. For example, a shift in attitudes toward a more conservation or environmental position may be hypothesized for both canoeing and noncanoeing specialists. Moreover, the underlying process of development may also lead to similar shifts in meaning derived from recreation participation. As they are measured now, the indicators of specialization are assumed to be the same for an activity group as a whole. This may be a reasonable assumption to the extent that the group is well defined, as in the case of trout fishermen. When trying to extend the concept to canoeists or backpackers, however, the concept breaks down. For example, not all backpackers may be participating in the same activity. Some may be climbers, others photographers, and still others, anglers.

The traditional indicators of specialization may not tap effectively the process of becoming specialized, which may apply to any recreation activity with the potential of high involvement. That is, current methods, while useful, may not be sensitive to how specialization changes the way participants process information or make decisions about their recreation opportunities. For this reason, Williams (1985) provided a description of the process of recreation specialization in terms of Flavell's (1972) cognitive development sequences. Viewed from the larger context of developmental theory this approach makes use of information processing perspectives that relate more directly to decision making processes.

Williams (1985) described specialization as the tendency to focus attention, acquisition of knowledge, or interest in one cognitive domain over another. Thus, specialization represents a cognitive style--a preference for and a way of thinking about the objects, events, or ideas of a domain that is comparatively advanced. Little (1976) described a specialist as: (1) one who is interested in and positively oriented toward a set of objects, ideas, or events (his specialty); (2) one who spends a comparatively large portion of his or her available time in activities involving the specialty; and (3) one who has a way of thinking about these objects, ideas, or events that is comparatively advanced. A key difference between Bryan's concept and the developmental-information processing approach is that the process of specialization is emphasized over content. Thus, a person may display a specialized orientation toward more than one recreation activity and at some point may be characterized as a highly skilled generalist rather than a narrowly focused specialist.

Further research on specialization needs to address the effects of the process of commitment to an activity separate from the effects of the content of specialization. The concept of recreation specialization has two components that must be addressed: the degree of involvement and commitment and the specification of the objects, ideas, or events to which a person develops a specialized orientation. The process of becoming highly involved and committed to recreation participation may not require specialization of "style" in activity participation as Bryan has emphasized.

REFERENCES

Bryan, Hobson. Leisure value systems and recreation specialization: the case of fishermen. Journal of Leisure Research. 9(3): 174-187; 1977.

Bryan, Hobson, Conflict in the great outdoors: toward an understanding of diverse sportsmen preferences. Sociological Studies No. 4. University, AL: University of Alabama, Bureau of Public Administration; 1979. 98 p.

Cordell, H. K., Hendee, J. C. Renewable recreation resources in the United States: supply, demand, and critical policy issues. Report for the national conference on renewable natural resources. Washington, DC: American Forestry Association; 1982. 88 p.

Driver, B. L.; Tocher, S. R. Toward a behavioral interpretation of recreational engagements, with implications for planning. In: Driver, B. L., ed. Elements of outdoor recreation planning. Ann Arbor, MI: University of Michigan Press; 1970: 9-31.

Flavell, John H. An analysis of cognitive-developmental sequences. Genetic Psychology Monographs. 86: 279-350; 1972.

Graefe, A. R. Understanding diverse fishing groups: the case of drum fishermen. Marine Recreation Fisheries. 6: 69-80; 1981.

Katz, M. An assessment of intra-group differences in conservation attitudes and environmentalism as a function of activity involvement among fly fishermen. University Park, PA: Pennsylvania State University; 1981. 277 p. Dissertation.

Kaufman, R. B.; Graefe, A. R. Specialization, expected rewards and resource related attitudes among canoeists. In: Witt, P. A.; MacNeil, R., eds. 1984 symposium of leisure research: abstracts; 1984 October 21-23; Orlando, FL. Alexandria, VA: National Recreation and Parks Association; 1984: 48.

Krumpe, Edwin E. Redistribution of backcountry use by a behaviorally based communication device. Fort Collins, CO: Colorado State University; 1979. 156 p. Dissertation.

Krumpe, Edwin E.; McLaughlin, William J. A model of recreationists' decisionmaking process. In: Lime, David W., tech. coord. Forest and river recreation: research update: proceedings of a symposium; 1981 October 25-27; Minneapolis, MN. Misc. Publ. 18-1982. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1982: 94-99.

Little, Brian, R. Specialization and the varieties of environmental experience: empirical studies within the personality paradigm. In: Wapner, S.; Cohen, S.; Kaplan, B., eds. Experiencing the environment. New York: Plenum Press; 1976: 81-116.

Manning, R. E.; Powers, L. A.; Mack, C. A. Temporal distribution of forest recreation. In: Lime, David W., tech. coord. Forest and river recreation: research update: proceedings of a symposium; 1981 October 25-27; Minneapolis, MN. Misc. Publ. 18-1982. St. Paul, MN: University of Minnesota, Agricultural Experiment Station; 1982: 26-32.

Nie, N. H.; Hull, C. H.; Jenkins, J. G.; and others. Statistical package for the social sciences. 2nd ed. New York: McGraw-Hill; 1975. 675 p.

Roggenbuck, Joseph, W.; Wellman, J. Douglas; Smith, Alan C. Specialization, displacement, and definition of depreciative behavior among Virginia canoeists. Final report prepared for the North Central Forest Experiment Station, U.S. Department of Agriculture. Blacksburg, VA: Department of Forestry, Virginia Polytechnic Institute and State University; 1980.

Shibutani, T. Reference groups as perspectives. American Journal of Sociology. 60: 562-569; 1955.

Tuan, Y. Space and place: the perspective of experience. Minneapolis, MN: University of Minnesota Press; 1977. 235 p.

U.S. Department of the Interior, National Park Service. National park statistical abstract. Washington, DC: U.S. Department of the Interior, National Park Service; 1984.

Wellman, J. Douglas; Roggenbuck, Joseph W.; Smith, Alan C. Recreation specialization and norms of depreciative behavior among canoeists. Journal of Leisure Research. 14(4): 323-340; 1982.

Williams, D. R. Relationship to place as a determinant of outdoor recreation preferences. Logan, UT: Utah State University; 1980. 116 p. Thesis.

Williams, D. R. A developmental model of recreation choice behavior. In: Stankey, G.; McCool, S., compilers. Proceedings--symposium on recreation choice behavior; 1984 March 22-23; Missoula, MT. General Technical Report INT-184. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985: 31-37.

FOREIGN VISITORS IN THE TAROKO NATIONAL PARK:

A STUDY OF RECREATIONAL EXPERIENCES AND OPINIONS TOWARD DEVELOPMENT

Lan-hung Nora Chiang

ABSTRACT: This study was carried out for the National Park Service of the Rep. of China for future planning and management purposes. Data were gathered through an onsite survey which included socio-economic characteristics, recreational experiences, and opinions of tourists toward present facilities and proposed developments in the Park.

INTRODUCTION

One and a half million visitors arrived in the Rep. of China in 1984, a 4% increase over the previous year. In order of importance by residence, they were from Japan, Hong Kong, United States, Southeast Asia, Europe, Australasia, and others (Tourism Bureau 1984). Advantages for developing international tourism include its strategic commercial location along the main airways to the orient; its relative political stability since 1945; and its phenomenal prosperity and development as a newly industrialized country. In addition, this island of approximately 19,000 sq. miles (36,000 sq. km.) offers a variety of natural and cultural landscapes which are easily accessible by a well-developed, integrated transportation system of railways, highways and airways that give access to all of Taiwan's regions. The island's economic prosperity favors development of international tourism which contributes to the generation of foreign exchange.

National Parks in Taiwan represent Taiwan's effort to preserve the island's diminishing natural areas and to provide recreational space. In an effort to meet international standards, Taiwan has adopted the standards of IUCN (Forster 1973) and has consulted international experts including those from the United States. Amounting to one-sixth of the national territory, four sites have been designated for national park development. These are Yanmingshan, Yu-shan, Taroko and Kenting.

The need for outdoor recreation has increased in Taiwan rapidly with urbanization, affluence, leisure time and improved transportation. But Taiwan has one of the greatest population densities in the world. This produced many pressures affecting land use so that the task of creating and managing national parks is enormously more difficult than in such spacious nations as the United States.

Paper presented at the National Wilderness Research Conference, Fort Collins, CO, July 23-26, 1985.

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PROBLEM

This study was conducted for the National Park Planning Service which is in the Ministry of Interior of Taiwan. For developing international tourism in Taiwan, on-site survey research adds value to surveys conducted by the Tourism Bureau in the departure hall of the airport. This paper contains information on socio-economic characteristics of international tourists, spatial behavior, and opinions towards facilities and developments that take place in the park.

THE TAROKO NATIONAL PARK

Outside of Taipei which is the capital city of Taiwan, the Taroko Gorge Recreation Area is the most frequently visited scenic site by foreigners. About 1,600,000 tourists come to Taroko Gorge each year and they generate approximately $25,000,000 U.S. per year.

Twenty-seven mountains in Taroko National Park are close to 10,000 ft. high. The park contains the major Liwu river which has carved a magnificent marble gorge, with numerous tributaries. Apart from the Gorge itself with the East-West cross-island highway along it, the surrounding environment covers an area of 92,000 ha. of land and supports a large diversity of plants and animals in a pristine environment.

RESEARCH FINDINGS

Method of Study

An on-site survey was undertaken for this research in which 90 foreign visitors were interviewed in the autumn of 1983 (Chiang 1984a). They were interviewed during October and November, months with the highest number of tourists in the year. Random sampling was used to select tourists, who were in different age and social groups and were using different modes of transport. As English was the language used in the questionnaire, only a small number of Japanese were interviewed although they constitute the largest proportion of tourists. Most foreign visitors interviewed came from America (47.8%) and Europe (25.6%). Others came from Asia, Africa and Australasia.

Two-thirds of the interviewees were in the 20-39 age group, a majority of them being male (62.5%) and half the total were single and more than half had a college education. The largest occupational group

was in business, followed by students, scientists and professionals. One-fifth of the respondents worked in Taiwan.

Spatial Behavior

As much as 40% of foreign visitors had been in the Taroko Area in the last five years. 60% had heard of Taroko Gorge before visiting. Most had been recommended by friends and relatives to visit the area or had obtained information through guidebooks, travel brochures or travel agents. Apart from two-thirds of the visitors who were accompanied by family members and friends, others were on guided tours, and 15% of all respondents travelled alone. More than half of the visitors stayed in the Taroko Area for one day only. Tour buses were the most used form of transportation, followed by taxicabs, private cars and walking.

The three major motivations for visiting the Taroko Gorge were sightseeing, being close to nature and seeking relaxation. Their major activities in the Taroko were sightseeing, phototaking, hiking, climbing and swimming in the hot springs area. Their greatest psychological rewards they reported were education (learning and exploring), relaxation, and getting a feeling of well-being.

Regarding existing facilities in the gorge, tourists were asked to express their satisfaction and dissatisfaction toward the cleanliness of environment, accommodation, price of food, frequency of buses and road conditions.

Dissatisfaction was infrequently expressed with the exception of opinion toward traffic conditions. The reason being that the tourists were delayed by traffic congestion on the East-West Highway which barely supports a two-way traffic.

Regarding existing facilities, they felt that walking trails and a tourist information center were the two most urgently needed. Among other facilities, toilets, garbage cans, drinking water and campground were needed. Regarding the means of disseminating information on the area's landscape and natural history, their priorities were pamphlets, visitor center exhibits, self-guided trails, roadside exhibits and guided tours.

Views toward Present Development in the Park

The idea of enlarging the present Taroko Gorge Recreation Area into a national preserve that will be Taiwan's third national park met universal approval among tourists, partly because of the scenic beauty and partly the high population density in urban areas. When asked to give their suggestions, the two foremost opinions are "to preserve nature as much as possible" and "to improve traffic conditions and road safety."

Along the Liwu river is the highway which provides access across the island. While serving as a thoroughfare, it also creates a bottleneck situation when the traffic is too heavy, reducing the safety level and creating serious problems of air and noise pollution. Since the overhanging cliffs along the road cannot be cut back farther, it is not possible to widen the road to create a through walkway or bikeway. A need arises therefore to keep the number of vehicles under control. The carrying demand on the road is seriously exceeded during the holidays. This adversely affects the experience of the tourist.

To answer the question: "If the Taroko Area is developed into a National Park, what suggestions would you like to make?" suggestions in order of importance are: minimize development and commercialization, keep the place clean, add hiking trails and campground, control tourism, provide maps and information in English, upgrade present facilities and educate the public about conservation through the mass media.

For most tourists, it was important "to keep the place as it is, as natural as possible"; and if facilities are added, they should be controlled and kept at the minimum in order not to spoil the natural environment.

At the time of the survey, several development projects were carried out which are in conflict with the goals of the national park. First, the Taiwan Power Company has proposed a series of dams on the upper tributaries of the Liwu River. The Power Company claimed that the impact on the environment would be minor and the artificial lakes behind the dams would even enhance the visual beauty. The company promised to carry out landscaping and conservation which would be included in the costs of hydro-electricity development. However, the electricity generated will only amount to 0.45% of all the electricity generated by all power sources in Taiwan. Secondly, the Formosa Plastics Corporation planned to build a cement plant complex in the delta which is four kilometers northeast of the proposed national park. The Corporation also believed that there would not be any negative impact on tourism by carrying out complete pollution control. This argument is poorly supported since several cement plants at the entrance to the Gorge have already defaced hillsides and have created air pollution. Thirdly, forestry development has constituted an economic activity that has accelerated soil erosion. In addition, mining activities at the expense of defacing the gorge continues to expand. Along the East-West highway, numerous hotels and restaurants which are responding to tourist's needs are exerting pressure on the natural environment.

When tourists were asked if they would permit hydro-electric power dams, mining operations, forestry and more hotels if the area were developed into a national park, the respondents to each item were in the proportions of 90%, 94%, 84%, 86% respectively.

CONCLUSION

The visitor survey would be useful in making recommendations for planning and management of the National Park. In order to meet the standards of IUCN for national parks, conservation is the foremost concern. All types of non-tourist

economic activities should be kept at a minimum. At the present time, tourism is concentrated in the eastern part of the Gorge. They would have to be directed to a larger area by information through exhibitions, brochures, interpretation, and signs in many foreign languages. Access to the less developed part of the Park would be improved by adding hiking trails for backcountry experiences.

Since the East-West highway is congested during public holidays and weekends, policies should be initiated to ensure safety and regulation of the traffic. Demand for accommodation could be met by facilities at Hualien which is the nearest city to the National Park entrance.

Development of National Parks in Taiwan would eventually contribute to international tourism. Publicity through written materials, such as a national park newsletter, and magazines which are published in foreign languages would help to inform international tourists before they come to Taiwan.

National parks are important resources to the 19 million people of Taiwan as well as a valuable resource to the citizens of the world. These park lands are significant ecosystems, and are significant as historical and cultural resources. Most importantly, in the highly industrialized, densely populated island of Taiwan, national parks provide areas for recreation and contemplation. Managing the national parks to prevent overuse and conflicting uses are major challenges for the recently formed National Park Service.

REFERENCES

Chiang, Lan-hung Nora. A Survey of International Visitors in the Taroko Area. National Park Service, Planning and Construction Department, Ministry of Interior, R.O.C.: 1984a. 129 p. Unpublished manuscript.

Chiang, Lan-hung Nora. Save Taroko Gorge - Our National Treasure. Taipei, Taiwan, R.O.C.: The Economic News, Tourism Special, No. 2895; 1984b. 36-37.

Forster, Richard R. 1973. Planning for Man and Nature in National Parks. IUCN, Morges, Switzerland; 1973. 85 p.

Tourism Bureau, Ministry of Communications. Report on Tourism Statistics, 1984. Republic of China; 1984, 44 p.

WILDERNESS VALUES IN DE FACTO WILDERNESS:

MANAGEMENT POLICY PERCEPTIONS OF MANAGERS AND COMMERCIAL USERS

James D. Absher and Leo H. McAvoy

ABSTRACT: This paper explores the management policy perceptions of resource managers and commercial users of a de facto wilderness. After discussing the rationale for this type of input into decision making and presenting the status of de facto wilderness on the Upper Mississippi River (UMR), data from a 1981 survey of managers and barge operators are presented to examine the perceptions on wilderness values and the future of wilderness areas on the UMR. A majority of both groups are not opposed to wilderness preservation, and there was substantial support for wilderness values. Support for wilderness by commercial users is a somewhat anomalous finding.

INTRODUCTION

Many scholars and activists argue that the 1.2 percent United States land base that is protected by congressional wilderness designation is too little, and that as a Nation we should promote legislation to preserve another 1 percent or so (Ralston 1985). Even so, another 2 percent is at least semiwild, and provides experiences with many wilderness values. In some of these areas, the experience is very wild indeed. Except for political reality, they might be candidates for wilderness designation: many are de facto wilderness. Whether or not the wilderness values will be explicitly managed for depends as much on the other uses to which the land is put as it does on the recreational or wilderness-dependent uses themselves.

This paper reports perceptions of individuals with close, firsthand knowledge of the Upper Mississippi River (UMR) de facto wilderness. The data are not from recreationists, but rather from resource managers and commercial barge operators who depend on the UMR for a livelihood. Their opinions were sought about the likely impacts of future commercial river developments on wilderness and the importance of preserving wilderness values on the UMR. We hope this paper will foster a better understanding of the manager/commercial users' input into agency and political decision making with respect to the fate of the de facto wilderness areas of the UMR. As an introduction, we first present some background on the nature and extent of de facto wilderness areas along the UMR. Then we turn to what is known about the role of wilderness-dependent recreation on the UMR. Third, there is a discussion of the policy and decisionmaking context within which the fate of wilderness values will be decided. Last, the introduction discusses the opinions and perceptions that are relevant to an assessment of future directions, concluding with the basic questions to be answered by the data.

The side channels and backwaters along the Upper Mississippi River (UMR) are a good example of de facto wilderness. The Upper Mississippi River stretches from Minneapolis, MN, to Cairo, IL. The backwater areas of the UMR will probably never come under the protection of the 1964 Wilderness Act. Yet they are Federal lands capable of providing recreational experiences consistent with the idea of wilderness. To a trained eye, human impact is evident, but for most recreational users the area offers many, if not all, of the essential wilderness qualities. In fact, the U.S. Department of the Interior, Fish and Wildlife Service once cataloged these areas for potential inclusion in the National Wilderness Preservation System (USDI-FWS 1977). In an area stretching about 300 miles along the UMR from just above Winona, MN, to just below Savanna, IL, the Fish and Wildlife Service identified approximately 194,000 acres of "lands and backwaters" with near-wild characteristics (fig. 1). Ultimately, wilderness designation was not pursued for these areas, but many of them remain de facto wilderness.

Why then do we feel that wilderness values are threatened? What is the status of wilderness-dependent recreation in the management of the UMR? The system of locks, dams, and other navigation structures along the UMR managed by the U.S. Army Corps of Engineers makes it a very efficient commercial transportation corridor. But that also means that backwater recreational use is of secondary importance. Waterway developments (such as wing dams) and maintenance procedures (such as channel dredging) are designed to facilitate barge traffic and can adversely

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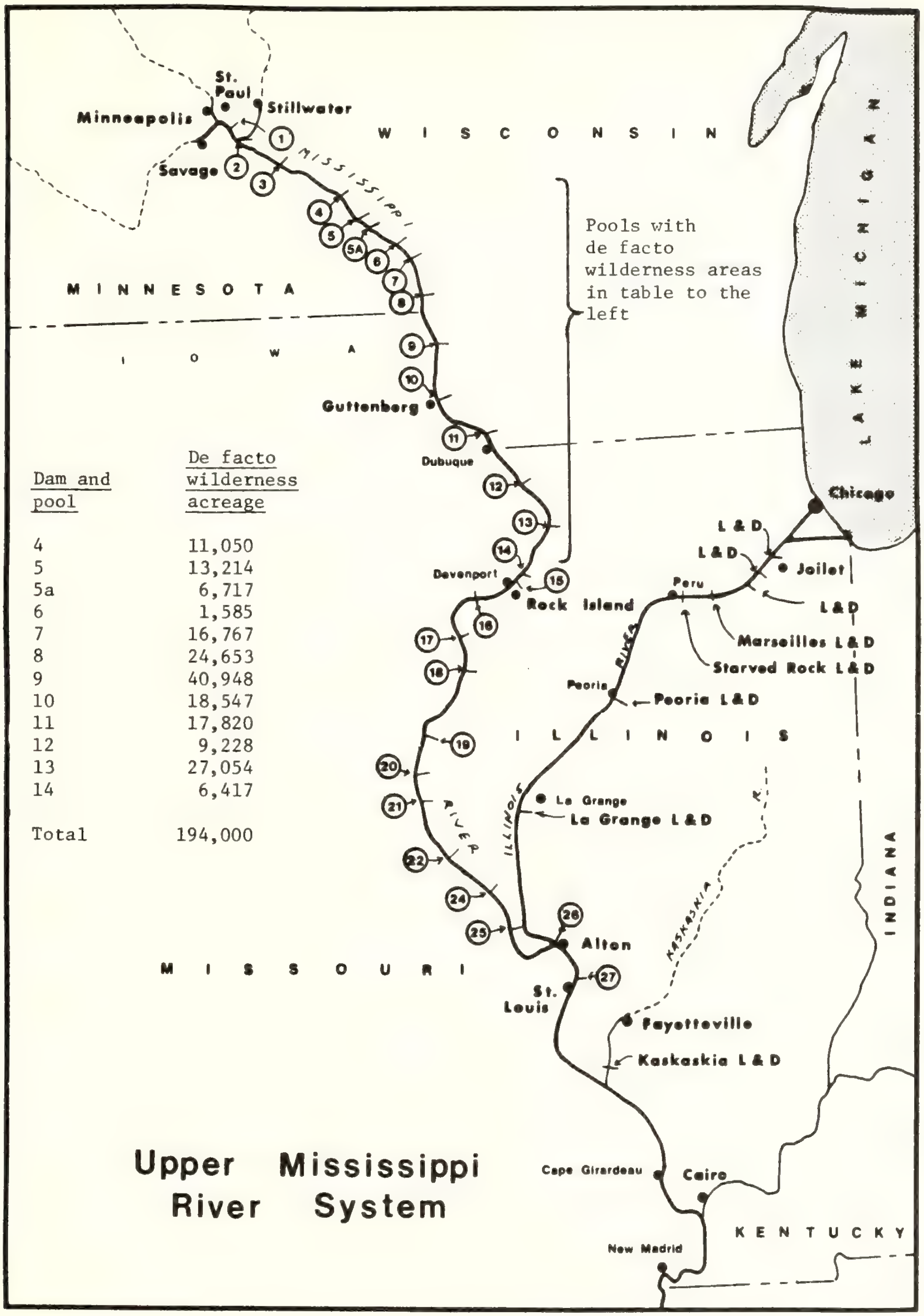

Dam and pool	De facto wilderness acreage
4	11,050
5	13,214
5a	6,717
6	1,585
7	16,767
8	24,653
9	40,948
10	18,547
11	17,820
12	9,228
13	27,054
14	6,417
Total	194,000

Figure 1.--De facto wilderness acreage on the Upper Mississippi River, by pool as identified in the 1977 survey. (Pools are the impounded river areas for each dam and are numbered alike.)

affect ecological relationships throughout the UMR. For instance, Absher (1982) reported that for selected backwater areas on the Illinois side of pools 16, 17, and 18 approximately 14 percent of the duck-blind sites were lost due to rapid siltation over a 7-year period.

Nonetheless, the UMR has become and continues to be a major recreational resource. A recent study estimated about 32 million recreation visitor days a year on the entire UMR (UMRBC 1982). Admittedly, most of this use is by motorized craft in and near the main channel. Just how much recreation use occurs on the 194,000 wildland acres was not estimated, but another study of UMR recreational users found over 30 percent of all respondents had visited for canoeing, hunting, fishing, or non-motorized boating at some time during the preceding year (River Research Consortium 1981).

Because most of the UMR is managed for other high priority outputs such as flood control and commercial navigation it is questionable whether resource managers desire, or will be able, to continue protection of values critical to wilderness recreation. With the completion of the new locks and dam No. 26 at Alton, IL commercial barge traffic volume is expected to increase 50 to 100 percent over the next 25 years. More intensive management of the river for all uses will be necessary. The most widely recognized recreational use conflicts are likely to be those between motorized recreational craft and commercial barge traffic (Gramann and others 1984). Wilderness-dependent recreation, and the resource base that supports it, may receive little attention.

Next, we wish to consider why it is important to know the opinions or perceptions of managers and commercial users of the UMR. For over 10 years a controversy existed about whether, and later how, to replace the old locks and dam No. 26 structure. On the surface, it was a simple case of interest group politics with each faction attempting to dominate or influence the decision process. But in reality the players in this fight were mainly the most vocal and powerful of the constituency groups. Throughout, little was said about wilderness values; they weren't seen as a major issue. It was left up to the professionals who manage the resource to stand up for these secondary issues.

Sociological literature suggests that in the absence of "fervent and substantial constituencies," management policies will be set without much public input. The public will be willing to follow or accept agency ideals, mostly because of a deep-seated belief in the right of "competent, legitimate professionals" to set policy (Gamson 1968). On the UMR, the wilderness users and motor boaters who might be directly affected by the loss of wilderness values have been either relatively unorganized and ineffective or not vitally interested in wilderness values. This acquiesence allows the future status of the backwaters to be decided by the resource managers, or the constituencies to whom they defer on questions of value. Hence managers' professional opinions and attitudes are extremely important to the future of the de facto wilderness. But because the wilderness values are only of secondary importance, it is not necessary for either group to have well-formed and strongly held opinions about them. This tendency to let agency personnel decide is reminiscent of Michels' (1962) suggestion that professionalism is the first step toward oligarchy. While we don't hold to this extreme view, the point is that just looking at recreationists' attitudes is insufficient.

Therefore, we turn to the decision makers and primary users of the resource to gauge their opinions about the wilderness issue. Such opinions form the basis of individual decision-maker's evaluation of policy alternatives (Quade 1982). Their viewpoint is a far better indication of the probable direction for de facto wilderness on the UMR, at least in the near future (Ruggie 1975). In a similar vein, recreation research literature suggests that the strength and longevity of management decisions will depend on managers' understanding of the relationship between potential changes in the resources system and current resource capability and use (Schreyer and Knopf 1984). Thus, this analysis will look at managers' and users' perceptions of the UMR de facto wilderness in four ways. First, what are the perceived effects of the dominant river use on the wilderness values? Second, do managers support the preservation of wilderness values for some areas along the UMR? Do they favor restrictive use policies to preserve these values? And last, are managers' views very different from those of the commercial barge industry?

METHODS

Data came from two sources: persons engaged in managing the recreation resource (park personnel, wildlife managers, rangers, lockmasters, marina operators) and employees of the dominant commercial river user--barge tow operators. Because the manager strata include businesses, this group is not purely representative of the recreational decision-making elite. However, only 23.7 percent of managers are from businesses that depend on commercial and recreational use of the river. The data are not encoded so that public employees and strictly recreation dependent businesses may be analyzed separately. During the spring and summer of 1981 survey crews

contacted each recreation resource site manager along the 1,200+ miles of the UMR. Similar contacts were made with a sample of registered commercial barge companies.

The instrument was a self-administered questionnaire. For the manager census, 366 questionnaires were distributed. With one wave of telephone followups, 258 were returned, for a response rate of about 70 percent. The barge operator sample, also with one followup, yielded 70 cases for analysis, for a 56 percent response rate. Those who worked along stretches of the river where wilderness qualities had been identified were asked to fill out an additional sheet of questions about this aspect of river use and management.

For analysis purposes, managers were divided into two groups to distinguish those who worked where wilderness qualities existed from those who worked elsewhere on the UMR. Therefore, three comparison groups exist: managers along wilderness-containing river stretches, managers from elsewhere on the UMR, and commercial barge operators.

RESULTS AND DISCUSSION

The first question elicited manager and barge operator perceptions about the probable effects of various hypothetical changes in the commercial use of the UMR due to expanded capacity at locks and dam No. 26. These hypothetical changes were a 50 percent increase in each of the following: (1) the number of barge tows, (2) the volume of dredged material disposed, and (3) the number of barge fleeting areas. Results (table 1) suggest that there is general agreement among respondent groups that some loss of de facto wilderness values is expected to occur due to expanded UMR operations. However, the commercial users either admit to less of an impact or none at all (mean scores of 2.99 to 3.22 where 3.0 is no effect). In turn, managers along non-de facto wilderness stretches perceived less legative impacts than did managers from pools where de facto wilderness acreage was identified. However, a t-test of the difference between the mean scores of the two groups of managers was not statistically significant at the 0.05 level.

The second question was whether managers support wilderness preservation along the UMR. Table 2 reports the data from both managers and commercial operators, but only those from pools with de facto wilderness acreage. Of these, there is a small proportion of managers (7.4 percent) that have no opinion on the matter. On the other hand, 34 percent of the barge operators expressed no opinion. This suggests that commercial users are not very concerned about the issue or at least feel that it is

Table 1.--Perceptions of the probable impact of expanded commercial activity along the Upper Mississippi River on areas with wilderness values, by respondent group. Mean responses with t-test between pairs of means for each impact item

	Managers from Pools:					
	With de facto wilderness		Without de facto wilderness		Commercial users	
Commercial activity to increase	Mean	N	Mean	N	Mean	N
Number of barge tows	[1]3.58^a	120	3.38^a	120	2.99^b	65
Dredged material disposal	3.60^a	117	3.30^a	116	2.72^b	64
Barge fleeting areas	3.73^a	115	3.64^a	115	3.22^b	64

[1]Means with different superscripts are significantly different at the 0.05 level of probability. Response categories were from 1 to 5 with 1=large increase, 3=no change, 5=large decrease.

Table 2.--Attitudes of managers and commercial users who work along UMR stretches of de facto wilderness toward wilderness classification on the Upper Mississippi River, by respondent group

Response category	Managers N	Managers %	Managers Adj.%	Commercial Users N	Commercial Users %	Commercial Users Adj.%
Favor classification	36	29.5	31.9	20	31.3	47.6
Favor, but not have on their stretch	51	41.8	45.1	14	21.9	33.3
Oppose classification	26	21.3	23.0	8	12.4	19.1
No opinion	9	7.4	--	22	34.4	--
	122	100.0	100.0	65	100.1	100.0

[1]Adjusted percentages are figured after "no opinion" respondents are discounted. A chi-square for the adjusted table is 3.11, which is not significant at the 0.05 level of probability.

unimportant to them. Of those expressing an opinion, the vast majority of both managers and commercial users are not opposed to wilderness classification. However, 45.1 percent of the managers and 33.3 percent of the commercial operators who expressed opinions prefer to be somewhere else in the system! A chi-square test for the table without "no opinion" responses is not significant at the 0.05 level of probability.

Overall, there is still substantial support for wilderness values, with the barge operators more favorable to the idea (47.6 percent) than the managers (31.9 percent). This may be explained by two factors. First, even though professionally predisposed to prefer natural values, many managers may feel that wilderness classification restricts their authority. Second, the barge operators may feel that because the riverway is a navigational system guaranteed by law, it is not threatened by wilderness classification. In fact, it may both enhance the scenic beauty of their job setting (the romance of Mark Twain is still alive) and help prevent increases in recreational craft that occasionally are navigation hazards in the main channel.

Table 3 reports data from the question that asked if the use of recreational motor craft should be reduced on river stretches containing wilderness or natural values. The managers from wilderness containing river stretches and the commercial users had essentially the same neutral mean response (2.96 and 3.03 on a 5 point scale; not significant at the 0.05 level). The managers from areas without

Table 3.--Attitude toward restriction of motor boats in natural wilderness areas, by respondent group; mean response and t-test between pairs of means

Statement	Managers from Pools: With de facto wilderness	Managers from Pools: Without de facto wilderness	Commercial Users
		Mean	
The use of recreational motor boats should be reduced on a few sections of the river that have outstanding natural or wilderness qualities	2.96[a]	3.24[b]	3.03[a]

[1]Means with different superscripts are significantly different at the 0.05 level of probability. Response scale was 1 50 5, where 1=strongly disagree and 5=strongly agree.

wilderness qualities mildly disagreed with the statement and were significantly different from either of the two other groups (mean of 3.42; significant at the 0.05 level). Thus there is no simple progression from wilderness-containing area managers to commercial users.

The anomaly here seems to be the barge operators' willingness to support wilderness values. Why would this be the case given the traditional opposition of commercial resource users such as timber and mining companies to wilderness classification? It isn't possible to discern whether this support, even though mild, stems from a purely ideological commitment to beauty and wilderness or is more tied up with concerns for preserving their traditional dominance of river use.

Perhaps barge operators' willingness to support wilderness is grounded in an appreciation for wilderness values and a desire to preserve those values. The survey of barge operators revealed a potentially possessive attitude toward the river. Barge operators are on the river every day of the navigation season and may have acquired an appreciation for the environmental beauty of the river and its surrounding areas. The survey indicated that these operators use the river extensively for their own recreational activities (such as boating, hunting, or fishing), and that 12 percent of them belong to volunteer conservation organizations. Maybe their lack of opposition to wilderness is based on an appreciation of wilderness values.

On the other hand, perhaps the barge operators' moderate support for wilderness is based more on their desire to maintain their dominance of management decisions on the river. If back-water areas are designated as wilderness, those areas will be closed to possible future development into residences, campgrounds, recreation-related businesses, marinas, and transportation corridors including roads and railroads. Development of these areas would create a new constituency that might be impacted by current or increased barge traffic on the river. This new constituency could challenge the current use and management dominance enjoyed by the barge operators. This is a rather cynical interpretation of the commercial users' willingness to support wilderness, but we believe it is a motivation that should be considered.

What are the implications of this support for decisions to maintain wilderness values? Because both managers and users support wilderness, it seems that a coalition of interests between the managers from wilderness-containing areas and commercial waterway users can exist. This classic "win-win" strategy does not rely on a coalescence of reasons, but only on a belief that the maintenance of wilderness values is in each group's own best interests, independent of the other.

CONCLUSIONS

In the end, it is possible to find evidence that suggests short term optimism over the fate of de facto wilderness along the UMR. Managers clearly have the mandate, and probably the decision-making power, to unilaterally decide the fate of these areas. Moreover, the data seem to suggest a differential sensitivity on the part of the managers toward wilderness values; there is more support from managers in pools where de facto wilderness exists.

The value set of the commercial barge operators isn't strongly adverse to wilderness, or they are apparently willing to let the managers decide on their own. In fact, the similarity of opinions of the two groups suggests that the commercial users of the river may be enlisted to support the preservation of wilderness in this instance.

The willingness of the commercial users to support, however moderately, wilderness values and preservation is a somewhat unique finding in this study. Some suggestions for further research include research into the wilderness-related values and attitudes of other commercial resource users and a more in depth investigation into the reasons or conditions under which commercial users will champion or fight wilderness classification. More generally, this study points to the need for better theoretical models of how opinions and attitudes of professionals and their constituents affect management policies on a regional scale.

On the Upper Mississippi, if formal wilderness designation were to once again be brought up, the local political support would be critical. But for the time being no strong support or opposition has been noted by either the resource managers or the commercial users. The future of de facto wilderness on the UMR is not so much in doubt as it is simply unknown.

REFERENCES

Absher, J. D. Recreation as a source of conflict in river basin management. Paper presented to the 15th annual meeting of the Mississippi River research consortium; 1982 April 14-16; LaCrosse, WI. Unpublished.

Gamson, W. A. Power and discontent. Homewood, IL: Dorsey Press: 1968. 208 p.

Gramann, J. H., McAvoy, L. H., Absher, J. D. and Burge, R. The relationship between commercial and recreational use of navigation locks on the Upper Mississippi River. Water Resources Bulletin. 30: 557-582; 1984.

Michels, R. Political parties. New York: Free Press; 1962. 370 p.

Quade, E. S. Analysis for public decisions. 2d ed. New York: Elsevier Science Publishing Co.; 1982. 380 p.

River Research Consortium. Evaluation of impacts of navigation and associated operation and maintenance procedures on recreation, potential wilderness and cultural resources of the Upper Mississippi River basin: final report. Minneapolis, MN: Upper Mississippi River Basin Commission; 1981. 320 p.

Rolston, H, III. Valuing wilderness. Environmental Ethics. 7: 23-48; 1985.

Ruggie, J. G. Complexity, planning and public order. In: LePorte, T. R., ed. Organized social complexity: challenges to politics and policy. Princeton, NJ: Princeton University Press; 1975. 373 p.

Schreyer, R.; Knopf, R. C. The dynamics of change in outdoor recreation environments - some equity issues. Journal of Park and Recreation Administration. 2: 9-19; 1984.

Upper Mississippi River Basin Commission. Comprehensive master plan for the management of the upper Mississippi River system. Minneapolis, MN: 1982. 181 p.

U.S. Department of the Interior, Fish and Wildlife Service. Wilderness study report. Winona, MN: U.S. Department of the Interior, Fish and Wildlife Service, Upper Mississippi Wildlife and Fish Refuge, Winona, Minnesota; 1977. 77 p.

MOTIVATIONS, SKILLS LEVELS, AND THEIR RELATIONSHIP IN MOUNTAINEERING

Alan Ewert

ABSTRACT: Why people climb mountains is a frequently asked question. "Because it's there" may be an adequate response for a documentary account but provides little information toward understanding the phenomenon of risk recreation. This study used factor analytic techniques to identify six underlying motivations for mountain-climbing. A discriminant analysis was employed to discern what factors could discriminate on the basis of reported skill level.

Factors generated by the analysis included: challenge, catharsis, recognition, creativity, locus of control, and the physical setting. Discriminant analysis indicated this instrument was somewhat useful in discriminating between novice, intermediate, and advanced individuals with respect to climbing skills.

INTRODUCTION

Why people engage in life-threatening recreational activities has been a frequently discussed question. With respect to one type of recreational endeavor, i.e., mountain-climbing, perhaps the most notable reply has been by George Leigh-Mallory, a noted British climber, who responded with his often quoted phrase, "because it is there" (Hunt 1954). He made this response shortly before his last expedition to the Himalayas, in which he and a fellow climber, Andrew Irving, disappeared into the mists at 27,000 feet on the northeast ridge of Mt. Everest, never to be seen again.

Concomitant to the growing popularity of risk recreation (Dunn and Gulbis 1976; Hutchinson 1980; Ewert 1985), has been an increase in research efforts attempting to define and characterize this type of activity. The term risk recreation is often synonymous with "outdoor pursuits," "high adventure programming," or "challenge programs." Risk recreation can be defined as those recreational activities that expose the participant to a real or perceived physical danger. Typical activities associated with risk recreation include: rock climbing, SCUBA, spelunking, winter camping and mountaineering. While the actual number of injuries and deaths is relatively low (Ewert and Johnson 1983), the perception of danger held by the participant is a critical aspect in many risk recreation activities (Ursin and others 1978; Helms 1982).

Just as perception is an important component in risk recreation, motivation[1] and experience also play important roles. Motivations in leisure activities have been a widely studied phenomenon with a number of studies done, particularly in traditional recreational activities such as sports and games (Tinsely and Kass 1979; Iso-Ahola and Allen 1982).

Within the risk recreation setting, several authors have attempted to describe the motivations and expectations surrounding that type of activity (Noyce 1958; Klausner 1968; Anderson 1970; Csikszentmihalyi 1975; Allen 1980). More recently, Mitchell (1983, p. 222), suggests a stress seeking urge in modern man which becomes the driving force in mountaineering. Similarly, Zuckerman (1979) has pointed to sensation-seeking as a prime motivator in an individual's life.

Studying the motivational dimensions in risk recreation is important because if participation in risk recreation continues to expand (Ewert 1985), many leisure delivery systems will be affected by this type of recreation. This trend has implications for the recreation provider since previous research has indicated the need for a strong linkage between the consumers' expectations and needs, and the wilderness recreation providers' perception of those needs (Jacob and Schreyer 1980; Brown and Haas 1980). Consistent with this role is the resource manager's need to accurately understand the motivations of the individuals involved in their areas of responsibility, to better meet the needs of those wilderness users.

In understanding the motivations for participating in risk recreation, it has been suggested that level of experience may be an influencing factor (Bryan 1979; Schreyer and others 1984; Schreyer and Lime 1984). In describing motivational differences within the same type of user group, Bryan (1979) has used the term "recreational specialization." He contends that as users gain greater experience in a specific recreational activity

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[1] For clarity, the term motivation refers to self-reported reasons for participation in a recreational activity.

their motivations for participation will change. This change will move from extrinsic types of rewards such as bagging a peak, to more intrinsic motivations, i.e., personal testing.

These findings concur with those of Schreyer and White (1979) who suggest that continued involvement in risk recreation activities involves a process whereby the individual focuses on the expected benefits of participation. Indeed, it would seem logical that as one becomes more aware of the myriad of risks involved in a risk recreation activity, the issue of expected benefits assumes greater importance. This is particularly apparent if one considers that an individual with greater experience is likely to have a more accurate perception of both the benefits and dangers in that particular activity. The beginner may be responding to imprecise perceptions learned through friends, family, or the media (Schreyer 1982).

Experience levels can represent both factual and perceptual connotations in that an individual's level of experience can be related to the number and type of mountain climbs participated in, or be based solely on the perceptions held by the individual concerning his/her own abilities and skills. As suggested by Schreyer, and others (1984) the selection of measures used to indicate experience levels becomes a trade-off between comprehensiveness and the constraints of the research setting. Lime and others (1981) report that separating recreational participants into experienced/inexperienced categories can result in significant differences between users.

Both motivations and the influence of experience level have implications for the management of wilderness areas. As previously discussed, wilderness managers have a need for accurate information concerning the users of their areas. Likewise, many wilderness areas have a variety of terrains and conditions which act as discriminating factors with respect to experience levels. In other words, a wilderness area may have terrain which is extremely rugged, containing difficult climbing or white-water routes, etc., and which, by its very nature, attract only the very experienced recreationalist. The same wilderness may also contain areas which are less extreme or demanding and will generally attract larger numbers of less skilled recreation seekers.

If specialization within a recreation activity, as characterized by greater experience levels, does influence motivations, then it seems reasonable to expect a set of divergent motivations within the same user type, i.e., canoeists, mountaineers, etc. To better understand these motivations and the effect of experience upon these motivations, the purpose of this study was two fold: (1) to ascertain the underlying reasons why people engage in mountaineering; and (2) to determine if these reasons vary with respect to level of climbing experience.

METHOD

Setting

The study was conducted at Mt. Rainier National Park, in Washington State, during the summer season in 1983. Mt. Rainier was chosen as the study site because of the unique climbing topography. Rising to 14,410 feet, the mountain stands as an isolated landmark visible to people from distances of over 100 miles. Because of its height, glaciation, and the variety of climbing routes, Mt. Rainier has received worldwide attention from the climbing community and is considered an important training ground for mountain climbers preparing for expeditions to the Himalayas or South American ranges.

The geography of the Mt. Rainier massif is particularly suitable for attempting to discriminate between climbing groups on the basis of experience level. The southern flanks of the mountain are generally considered the least demanding in terms of climbing difficulty (Beckey 1973) and are where the greatest number of guided parties are conducted. Because of these factors, the southern flanks receive the largest percentage of low-skilled climbers.

The northeastern flanks are generally considered slightly more difficult and certainly more remote than the Paradise [southern] side and are usually climbed by people of an intermediate or novice level of climbing skill. The entry point for these slopes is generally the White River Ranger Station (ca. 2000 ft.)

The northwestern slopes are deemed the most difficult climbs on Mt. Rainier and involve steep glaciated headwalls, cirques, and ridges. Climbers attempting these areas are usually highly skilled and enter these areas through the Carbon River Ranger Station (ca. 2000 ft.).

Data Collection

In order to examine the perceived leisure needs of novice and intermediate climbers as well as those of advanced climbing skills, a 40-item questionnaire was distributed by eight people stationed at the various entry points, i.e., three at the Paradise Ranger Station (southern slopes), three at White River Ranger Station (northeastern slopes), and two at Carbon River Ranger Station (northwestern slopes). The data collectors distributed questionnaires to climbers who were about to embark on their respective climbs. Data collection was conducted before the individual's climb[2] to control for the effect of climbing success as described by Driver and Knopf (1977).

The 40-item instrument was constructed to measure subjects' reported leisure needs. Many of the

[2] This period can be likened to the anticipation phase of an outdoor recreation experience originally described by Clawson and Knetsch (1966) and substantiated by Hammitt (1980).

items were selected on the basis of their perceived ability to measure the leisure motivations previously identified in leisure research (Crandall 1980; Iso-Ahola and Allen 1982). Some items were constructed by the author from past experience as a climber and were considered relevant to the activity of mountain-climbing. These items included: to enjoy the wilderness and to be known as a mountaineer. Subjects responded to these items on a five-point Likert scale anchored by the statements "strongly agree" and "strongly disagree".

In order to determine experience level, respondents were asked to rate themselves with respect to perceived climbing skill as a novice/beginner, intermediate or advanced climber.

DATA ANALYSIS AND INTERPRETATION

Out of 480 climbers queried, 460 usable questionnaires were obtained (96% total return). Of these, there were 372 men (80.9%) and 78 women (17%). Subjects' ages ranged from 14 to 65 with a mean age of 29.65 years. Within this study, 38.1 percent called themselves novice climbers, with 52.2 percent indicating their skills to be at the intermediate level, and 9.4 percent calling themselves advanced in climbing skills.[3] When compared with reported years climbing, some interesting observations were noted. An overall X^2 probability of .000 suggested a systematic relationship between number of years of climbing experience and skill level. The gama statistic of .622 ($p = .000$) and Pearson's R (.41, $p = .000$) supported this finding. In using status (novice, intermediate, advanced) as the dependent variable, an ETA of .611 was generated with 37 percent of the variance explained by this relationship.

Of interest was the specific relationship of years climbing with self-reported skills. The data indicated that 65.0 percent (N = 96) of the novice climbers had 0 to 2 years of climbing experience with a mode of less than 1 year of climbing, suggesting that this may have been their first trip. Those respondents who reported their climbing skill at the intermediate level generally had from 2 to 5 years of climbing experience (N = 86; 39 percent) with a mode of 4 years. Those individuals with an advanced skill rating had a general range of 3 to 10 years of climbing experience (N = 24; 57.8 percent) with a mode of 7 years.

Within the parameters of this study, it appears that somewhere around the second year of climbing, the individual begins to think of himself as moving from a novice climber to one of intermediate experience. Similarly, the intermediate skilled mountaineer begins to think of himself as advanced around the fourth year of climbing.

[3] The data were similar to that obtained through a National Park Service study conducted at Mt. Rainier during July and August, 1980. A copy of the study can be obtained through the National Park Service, Mt. Rainier National Park, Washington 98576.

Within this study, no attempt was made to determine actual number of climbs and types of climbs participated in. While this can be viewed as a weakness of the study, it should be noted that an individual's self-perception of climbing ability is of paramount importance. An individual climber may have excellent technical skills but view himself as being relatively inexperienced and behave accordingly. The converse of this is also true, with individuals who have low levels of experience but feel they are highly skilled.

Factor Analysis

In order to achieve a more parsimonious representation of the underlying motivations for mountain-climbing, a principal component factor analysis was performed with a final solution achieved by varimax rotation. This analysis produced six factors with an eigenvalue of one or greater and accounted for 85.5 percent of the total variance. The criterion value for including an item into a factor was .35. Table 1 presents the factor loadings after varimax rotation. A chi-square test of significance of a correlation matrix produced a value highly significant (.001), thus indicating the propriety of a factor analysis solution (Barlett 1950).

Descriptive terms were used to distinguish among the six factors. These terms included: (1) challenge/risk; (2) catharsis; (3) recognition; (4) creativity; (5) locus of control; and (6) setting. All six factors achieved reliabilities of .69 to .75 with an overall Cronbach alpha of .89 suggesting a moderately consistent pattern of response to each factor (See table 1). With respect to individual means for each dimension the following values were observed: physical setting (4.50); challenge/risk (3.90); catharsis (3.31); locus of control (3.28); creativity (3.20); and recognition (2.23).

Interpretation of the Factors

Factor I: challenge/risk.--This dimension was clearly related to an element of challenge and personal risk as evidenced by the loadings on the statements: to test myself (.62), for the excitement (.59), to develop my skills and abilities (.57), to experience feelings of accomplishment (.56), to develop my physical skills (.54), to experience feelings of exhilaration (.51), and because of the risks (.42). This type of grouping would be expected if one considers the very essence of mountain-climbing, i.e., a deliberate intrusion into often dangerous terrain and hostile weather conditions.

Factor II: catharsis/escape.--The second factor was termed catharsis/escape because of the loadings on the following variables: to relieve stress (.69), so my mind can slow down (.65), relaxation (.56), to get away from responsibilities (.52), solitude (.44), and to think about personal values (.40). The act of mountain-climbing requires a

Table 1.--Varimax analysis of leisure needs in risk recreation (mountaineering)[1]

Leisure Needs	Rotated Factor Loadings						Commonality
	I	II	III	IV	V	VI	(h^2)
enjoy the wilderness	01	14	-06	00	05	83	73
view the scenery	13	13	-06	-03	03	73	59
physical exercise	20	11	01	-02	01	23	55
exhilaration	51	21	13	-01	00	28	44
accomplishment	57	04	25	06	06	18	48
spiritual reasons	17	28	14	24	00	22	29
recognition from others	11	04	71	02	07	-06	58
solitude	07	44	-10	24	-06	19	35
part of a group	02	04	22	13	17	-02	50
relaxation	06	56	-13	08	02	12	45
so mind can slow down	07	65	00	12	09	09	50
do things with friends	08	15	06	14	09	10	34
meet people of opposite sex	00	11	21	31	16	-03	33
bring family together	04	21	35	18	04	14	26
to show others I can do it	16	01	70	02	09	-07	53
excitement	59	01	06	04	08	15	48
develop skills and abilities	57	04	-02	20	22	-02	46
something to do	16	11	17	28	-03	-04	36
physical skills	54	-01	02	23	07	-10	48
to help others	12	10	06	50	29	03	43
to be creative	29	31	09	43	24	00	47
get away from responsibilities	01	52	11	05	07	05	39
be close to nature	19	21	-02	23	02	53	52
personal testing	62	08	21	01	16	02	51
job related	00	-07	12	44	09	-01	26
to be known as a "mountaineer"	11	-03	54	30	11	-01	44
photographic reasons	-05	13	05	37	04	12	18
to use the mind	32	22	02	53	34	00	56
to think about personal values	17	40	19	41	25	10	56
competition	15	01	45	09	25	-11	43
to avoid boredom	03	13	25	19	17	-09	52
opportunities to make decisions	29	05	02	30	61	-06	58
friendships	11	02	11	22	50	10	54
gain control	11	05	26	08	50	04	36
keep physically fit	21	09	06	14	16	04	66
because of the risks	42	11	09	-09	34	03	51
team effort	17	06	12	23	53	00	49
get away from authority	07	35	08	16	30	04	38
relieve stress	-02	69	07	-07	14	09	53
self-expression	34	38	15	13	20	04	35
Eigenvalues	7.42	2.85	1.86	1.36	1.26	0.97	
Percentage Variance	40.30	15.50	10.20	7.40	6.90	5.30	
Cumulative Percent	40.30	55.80	66.00	73.40	80.20	85.50	

[1] Decimal points have been omitted.

high degree of concentration similar to the autotelic "flow" experience described by Csikszentmihalyi (1977) or the "push" from a structured life space to a temporary involvement into a non-structured recreational life space as suggested by Driver and Tocher (1974, p. 13).

Factor III: recognition.--The third factor was termed recognition because of the following loadings: recognition from others (.71), to show others I can do it (.70), to be known as a mountaineer (.54), and competition (.45). Mitchell (1983, p. 86) suggests that clubs and organizations play an important role in mountain-climbing, even to the extent that some groups have "mountaineers lists" and other status symbols.

Factor IV: creativity.--The fourth dimension was called creativity because of the loadings on the variables: to use my mind (.53), to help others (.50), to be creative (.43), and to think about personal values (.41). The topic of creativity has been alluded to in various mountaineering literature (Rowell 1977, p. 111). The problem-solving intricacies included in mountain-climbing involve decision-making, route selection, terrain analysis and a merging of an individual's cognitive and affective milieu with his or her physical skills. This effort is stimulated by the physical danger often present in the mountain-climbing situation. It is the author's feeling that the factors of catharsis and creativity are closely linked as evidenced by the .57 correlation between Factors III and IV.

Factor V: locus of control.--Factor V was termed locus of control because of the loadings on the following variables: the opportunity to make decisions (.62), to contribute to team effort (.53), and to gain control over myself and others (.50). These findings support an earlier work (Schreyer and White 1979) which speaks of an individual's desire to seek some aspect of control over his or her environment in a risk recreational setting. It appears that individuals engaged in this risk recreation activity may do so, in part, to demonstrate a sense of control over a portion of their lives when actively engaged in mountain-climbing.

Factor VI: physical setting.--The term physical setting was chosen as the descriptive because of the loadings on the variables: to enjoy the wilderness (.83), to view the scenery (.73), and to be close to nature (.53). Besides the factor challenge/risk, the physical setting would seem to be a logical motive. A substantial amount of literature supports the view that the setting plays an important role in an individual's use of the outdoors for a recreational activity (Hendee and others 1978). With respect to wilderness recreation, the general connotation has been to associate the physical setting as a "testing ground" for the individual. The findings of this study support the view that individuals involved in mountain-climbing consider the physical setting an important aesthetic and scenic motivation. Indeed, it would seem unlikely that the grandeur of mountain settings would go unnoticed and unsought by many climbers.

Analysis of Factors

To further identify the effect of experience on the six dimensions generated from the above factor analysis, a one-way ANOVA was performed using the mean scores of each factor across the three skill levels, i.e., novice, intermediate, and advanced. Significant differences ($p < .05$) were noted for items in the three factors; Challenge/Risk, Recognition, and Locus of Control. The results of this analysis are presented in table 2.

Using mean scores, physical setting is of paramount importance to the climbers in this study. This importance was consistent for all three groups of climbers (novice, intermediate, and advanced). Another factor of great importance to the respondents was the factor challenge/risk. Within this factor, the greater the experience level the greater the importance placed upon this dimension. This trend was also evident in the locus of control factor with the more experienced climbers expressing greater agreement with this dimension. The other factors of catharsis and creativity showed little differentiation between groups. Recognition, a factor of obvious externally oriented dimensions, was viewed more importantly by the novice climber than by the intermediate or advanced individual.

Discriminant Analysis of Items

To look at the effect of experience level on motivations from the individual item perspective, a step-wise discriminant analysis was performed using the items comprising each underlying factor. The results of this analysis are shown in table 3.

While Function 1 was statistically significant, considering the large sample size, a multivariate analogue of "omega squared" (Tatsuoka 1970) was generated ($W^2 = .18$). The low Omega square suggests a relatively low discriminatory power of the discriminant functions, i.e., experience levels.

However, upon generating a correct classification table, it was found that 46.74 percent of the cases were correctly classified. Of the three groups, 57.6 percent of the novice climbers, 37.9 percent of the intermediate level climbers, and 51.2 percent of the advanced climbers were correctly classified. When these data were applied to the t-test procedure as advocated by Brown and Tinsley (1983) a value of 6.29, $p = .000$, was realized. It was concluded that with respect to correct classification, a proportionality of 46.74 was significantly better than the 33.0 correct classification which would be expected by change alone.

While not a strong influence, it appears that skill level does play a role in affecting an individual's motivations for mountain-climbing. From the

Table 2.--Oneway ANOVA data of factors and significant items by experience level

Factor	Overall Mean[1]	Group Means[2] Nov.	Int.	Adv.	Probability
CHALLENGE/RISK (I)	3.94	3.82	3.93	4.08	.09
Develop skills	4.06	3.92	4.14	4.12	.02
CATHARSIS (II)	3.34	3.32	3.31	3.39	.99
RECOGNITION (III)	2.27	2.35	2.20	2.12	.68
To show others	2.15	2.36	2.13	1.98	.04
To be a "mountaineer"	2.17	2.38	2.14	2.00	.07
CREATIVITY (IV)	3.23	3.15	3.23	3.30	.60
LOCUS OF CONTROL (V)	3.30	3.17	3.33	3.40	.08
To make decisions	3.01	2.81	3.04	3.17	.05
PHYSICAL SETTING (VI)	4.50	4.50	4.50	4.49	.78

[1] Higher score indicates stronger agreement with factor

[2] Novice, intermediate, advanced

Table 3.--Statistics from discriminant analysis

Function	Eigen-value	Relative Percent	Canonical Correlation	Wilk's Lambda	Chi-Square	Significance
1	.102	78.8	.30	.883	50.35	.001
2	.027	21.2	.16	.973	10.96	.447

Item (Factor)	Standardized canonical discriminant coefficients: Function 1
To test myself (I)	.35
For the excitement (I)	-.02
To experience feelings of exhilaration (I)	.29
Get away from responsibilities (II)	.00
To show others I can do it (III)	.81
Know as a "Mountaineer" (III)	.50
Use my mind (IV)	-.05
To make decisions (V)	.34
To develop skills (V)	.17
To be close to nature (VI)	.49
To enjoy the wilderness (VI)	.46
To view the scenery (VI)	.32

analyses, the individual items of personal testing, recognition and to make decisions appear to be areas of change dependent on skill level. Consistently, the more skilled and presumably experienced an individual, the greater the propensity to seek internal motivations such as challenge, personal testing, or decision-making. Conversely, the less skilled individuals more often sought out external rewards such as recognition or to show others. Mean scores suggested that skilled climbers also more strongly agreed with aspects of seeking creativity while there was little distinction evident in physical setting (most highly sought after by all groups) and catharsis (highly agreed with).

DISCUSSION AND IMPLICATIONS

The present findings have several implications for wilderness managers and recreation programmers. While risk recreation is only recently a popular phenomenon, it has attracted a growing number of participants. This popularity has grown to the extent that many recreation and wild areas could be and are being impacted.

From an applied point of view, motivational factors for participation could be translated into desired recreational experiences. For example, if one recreational motivation is challenge, it seems resonable to expect a diminished perceived recreational outcome if that particular need is insufficiently satisfied. As previously mentioned, dealing with these recreational needs is a critical role of the resource manager (Driver and Brown 1975). With respect to Mt. Rainier, this has been a historical point of contention with a few individuals advocating a physical altering of some of the climbing routes to allow for greater safety and less risk. It appears from this study, individuals of this persuasion may not speak for all climbing populations, if in fact, these physical alterations reduce the perception of challenging climb.

However, the findings of this study have suggested that motivations change as a person becomes more highly skilled in a particular recreation activity. This movement being from external types of motivations to more introspective or internal dimensions. Thus, homogeneous management policies, as is still the case in many wilderness areas, may not be the most conducive to user satisfaction. This is particularly true in areas which have a wide diversity of topography which attracts differently skilled individuals. This study suggests that areas or climbing routes which attract the more skilled mountaineer should be kept more rugged, less crowded, and less obtrusively controlled to allow for greater perceptions of challenge, risk-taking, and locus of control. Those areas in which the less skilled individual is more likely to recreate in can be better managed to allow for more use, socialization opportunities, and obtrusive controls such as patrolling rangers, etc.

From this study, the question "Why do people climb mountains?" may be addressed in a multi-dimensional framework with reasons including: because they seek a challenge or risk, a cathartic experience, recognition as a mountain climber, a creative experience, an opportunity to gain control over their lives for a period of time, and because of the physical setting. Similarly, three of these reasons: challenge, recognition, and control, appear to contain items which vary with respect to skill level, with advanced climbers appearing to be more strongly motivated by the challenge, opportunity to experience a sense of control over their lives, and are less motivated than the novice climber because of recognition. These findings add support to the recreation specialization theory advocated by Bryan (1979).

Given the low discriminatory power realized in this study, future research should seek to replicate these findings on mountain-climbing and other wilderness-user populations. This type of information could be added to the expanding data base concerning leisure motivations and desired benefits. Another area fertile for continued research would be the points at which climbers begin to think of themselves as members of the next higher skill level. Is this perception garnered around number of climbs, types of climbs, experienced recognition, or a combination? Understanding this phenomenon will also help better understand the risk recreationalist. In an era of increasing use coupled with decreasing resources, the greater the knowledge about wilderness users, the more likely the wilderness manager will be to make the correct decision.

REFERENCES

Allen, S. Risk recreation: some psychological bases of attraction. Ph.D. Dissertation. University of Montana; 1980.

Anderson, J.R.L. The ulysses factor. New York: Harcourt, Brace, Jovanovich, Inc.; 1970.

Bartlett, M. S. Test of significance in factor analysis. British Journal of Psychology. 3:77-85; 1950.

Beckey, F. Cascade alpine guide. Seattle: The Mountaineers; 1973: 83-126.

Brown, P. J. and Haass, G. E. Wilderness recreation experience: the Rawah case. Journal of Leisure Research. 12(3): 229-241; 1980.

Brown, M.; Tinsley, H. Discriminant analysis. Journal of Leisure Research. 15(4): 290-310; 1983.

Bryan, H. Conflict in the great outdoors. University of Alabama, Bureau of Public Administration, Social Studies no. 4.; 1979. 98 p.

Clawson, M.; Knetsch, J. Economics of outdoor recreation. Baltimore: The John Hopkins Press; 1966.

Crandall, R. Motivations for leisure. Journal of Leisure Research. 12(1):45-54; 1980.

Csikszentmihalyi, M. Beyond boredom and anxiety. San Francisco: Jossey-Bass, Inc. 1977.

Driver, B. L.; Brown, P. J. A socio-psychological definition of recreation demand, with implications for recreation planning. Assessing demand for outdoor recreation. National Academy of Sciences: Washington, D.C.: 1975: 62-88.

Driver, B. L.: Knopf, R. C. Personality, outdoor recreation and expected outcomes. Environment and behavior. 9(2): 169-193; 1977.

Driver, B. L.: Tocher, S. R. Toward a behavioral interpretation of recreational engagement, with implications for planning. In: Driver, B. L., ed. Elements of outdoor recreation planning. Ann Arbor, MI: University of Michigan Press; 1970: 9-31.

Dunn, D. R.; Gulbis, J. M. The risk revolution. Parks and Recreation. 11:12-17; 1976.

Ewert, A. Emerging trends in outdoor adventure recreation. Paper presented at the Outdoor Recreation Trends Symposium II. Myrtle Beach, South Carolina; 1985 February 26.

Ewert, A.; Johnson, B. Current trends and issues in outdoor recreation. Paper presented at Pacific Northwest Recreation and Park Association Convention; 1983 April 21.

Hammitt, W. E. Outdoor recreation: is it a multiphase experience? Journal of Leisure Research. 12(2): 169-193; 1980.

Helms, M. Factors affecting evaluations of risks and hazards in mountaineering. Journal of Experiential Education. 7(3): 22-24; 1984.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Washington, D.C.: U.S. Government Printing Office; 1978; Miscellaneous Publication No. 1365.

Hunt, J. The conquest of the summit. National Geographic. 151(1): 8; 1954.

Hutchinson, I. J. Risk-taking in the national parks--reality and managerial reflections. Risk and accidents in outdoor recreation areas: selected papers; 1980. Information report no. 80-1, Texas A&M: 104.

Iso-Ahola, S. E.; Allen, J. The dynamics of leisure motivation: the effects of outcome on leisure needs. Research Quarterly for Exercise and Sport. 53(2): 141-149; 1982.

Jacob, G.; Schreyer, R. Conflict in outdoor recreation: a theoretical perspective. Journal of Leisure Research. 12(4): 368-380; 1980.

Klausner, S. Z., ed. Why man takes chances. Garden City, New Jersey: Doubleday and Company; 1968.

Lime, D.W.; Knopf, R. C.; Peterson, G. L. The national river recreation study: growing new data base with exciting potential. In: Some recent products of river recreation research. Gen. Tech. Rep. NC-61. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981: 1-8.

Mitchell, R. G. Mountain Experience--Psychology and Sociology of Adventure. Chicago: The University of Chicago Press; 1983. 272 p.

Noyce, W. The springs of adventure. New York: World Publishing Co.; 1958.

Rowell, G. In the throne room of the mountain gods. San Francisco: Sierra Club; 1977.

Schreyer, R. Experience level affects expectations for recreation participation. In:D. W. Lime, ed. Forest and River Recreation: Research Update. St. Paul: Minnesota Agricultural Experiment Station. Misc. Publn.; 18-1982: 154-159.

Schreyer, R.; White, R. A conceptual model of high-risk recreation. In: Proceedings of 1st Annual National Conference on Recreation Planning and Development. New York: American Society of Civil Engineers, Vol. I.; 1979: 191-194.

Schreyer, R.; Lime, D.; Williams, D. Characterizing the influence of past experience on recreation behavior. Journal of Leisure Research. 16(1): 34-50; 1984.

Tatsuoka, M. Discriminant Analysis: The Study of Group Differences. Champaign, Illinois: The Institute for Personality and Ability Testing; 1970.

Tinsely, H.; Kaas, R. The latent structure of the need satisfying properties of leisure activities. Journal of Leisure Research. 11(4): 278-291; 1979.

Ursin, H.; Baade, E.; Levine, S. eds. Psychobiology of stress. New York: Academic Press; 1978.

Zuckerman, M. Sensation Seeking: Beyond The Optimal Level of Arousal. Hillsdale, New Jersey: Lawrence Erlbaum Associates; 1979.

Section 8. Wilderness Benefits Research

INTRODUCTION: BENEFITS OF WILDERNESS

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Session Coordinator

Outdoor recreation resources in the United States were used on over one billion occasions last year. Over half the adult population went fishing and 35 percent camped in a developed site at least once. There is no lack of evidence that people use natural resources for recreation when they are available. Further, trips are planned to view mountains, lakes, rivers, forests, and other such resources. Even those who have no plans to visit such special environments want them preserved for themselves and future generations.

However, knowing that many people travel considerable distances and invest their time and money to experience such environments is not enough. There is always the question "Why?" What are the dimensions of the benefits anticipated and realized? Also, there is the parallel question of "How much?" Values are measured in many ways. Economic values are expressed in dollars or some other exchange value. Yet, we are often uncomfortable with placing a dollar value on just what may be most crucial to our lives--love, intimacy and communication, beauty, joy, and any unique experience.

Wilderness may be just such a value for many of us. Even if we live so far from treasured environments that we may go some years without entering them ourselves, we recollect past experiences, anticipate future ones, and want nothing to deny the same possibilities to our children and grandchildren. So, if some government agency decrees that they must have a dollar proxy for this valuation, we are willing to play the game . . . with clear reservations.

The paper by Kenneth Barrick addresses the option value issue and employs a diverse set of samples to measure issues of use vs. nonuse and distance. Again, the significance of preservation for nonusers, even at a distance, is supported despite the much higher values placed by those who have visited or are most likely to visit the resource.

There are now a number of classifications of benefits. One distinguishes use from preservation. Another classifies personal, societal, and economic benefits. Some are specific to particular resources. Some are based on recollected experiences. Some employ proxies for a person's "willingness to pay" for the resources's use or preservation.

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Measurement may be comparative or quantitative. A variety of methods have been employed to obtain such measures: surveys, scales, economic indices, simulations, narratives, behaviors, and actual markets. Each, however, seems to tap only parts of the total meaning of a resource to all who value it. Each has some bias or limitation.

So, at present we are in a condition of triangulation. That is, we continue to use many measures, indices, approaches, metaphors, and combinations. We are skeptical about the accuracy and completeness of any and all. And we will go on with our efforts to do it better, whether we ever expect to "get it right" or not.

The papers that follow are marked more by their variety than their consistency. While the economic approaches seem to be complementary, it would be difficult to integrate them fully with some of the experiential, philosophical, theoretical, and site- or program-specific studies that are also included. I would argue that there is value in diversity. At least, there is likely to be one paper that offers an idea, a question, or a doubt that we may not have encountered before. The fun of it all is that it will not be the same paper for everyone. We could even call that learning.

PUBLIC BENEFITS OF WILD AND SCENIC RIVERS

Richard G. Walsh, Larry D. Sanders, and John B. Loomis

ABSTRACT: The purpose of this paper is to illustrate how to measure the economic benefits and costs of rivers to the general public. Procedures for estimating recreation use and preservation values are applied to the problem of wild and scenic river protection in Colorado.

INTRODUCTION

Water is of increasing concern to the citizens of Colorado and the West--how to preserve what we have, plan for the needs of an expanding population and industrial base, provide for agriculture, and achieve a balance between environmental quality and development. As the economy grows, increasing demands are made on rivers. In the past, most western communities welcomed new dams and water diversions as a source of income and economic growth. As a result, almost one-third of the 12,500 miles of river in Colorado have been adversely affected: nearly 10 percent have been diverted or inundated by reservoirs and 20 percent have been polluted, according to state studies. More recently, citizens of the state have begun to question whether some rivers should be protected from further water development. In a balanced approach, some rivers or sections of rivers would be best suited for development and others for protection.

At the present time, no rivers in Colorado are protected either by the state or by federal designation as recreational, wild, or scenic rivers. Sections of 11 rivers were recently studied by federal agencies and found to be suitable for protection. These 11 rivers represent about 4.5 percent of the total miles of rivers in the state, and include: Cache la Poudre, Colorado, Conejos, Dolores, Elk, Encampment, Green, Gunnison, Los Pinos, Piedra, and Yampa Rivers. Since this study, several bills have been introduced in the U.S. Congress to protect several of these rivers under the Wild and Scenic Rivers Act of 1968. There is a need: (1) to develop information on the economic benefits of river protection; (2) to make it available to the people involved at the local, state, regional, and national levels; and (3) to help our representatives in government make decisions about the future use of rivers.

The Wild and Scenic Rivers Act of 1968 (PL 90-542) provides that selected rivers or sections of rivers may be protected in their natural free-flowing condition. Protecting rivers under the act would mean no further construction of dams, reservoirs, water diversions, and other development incompatible with free-flowing rivers. Existing multiple uses would continue, so long as the rivers are protected essentially in their natural condition. The multiple uses include the following: recreation activities such as fishing, boating, hunting, hiking, camping, sightseeing, and staying at resorts; livestock grazing and ranching; living in mountain homes; watershed protection; and timber harvesting.

Most of the study rivers qualify for wild river designation. Of the 555 miles recommended for protection, 324 miles are qualified as wild rivers, 101 miles scenic, and 130 miles recreational. The Act defines the characteristics of each as follows:

(1) Wild river areas--those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

(2) Scenic river areas--those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

(3) Recreational river areas--those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

The economic evaluation of potential wild and scenic rivers has traditionally focused on the benefits and costs of recreation use. Several studies have estimated aspects of the demand for cold water fishing, boating (rafting, kayaking, and tubing), and related shorelines uses (primarily sightseeing, camping, and hiking). These include studies of the recreation use value of instream flow in the Cache la Poudre River

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(Daubert and Young 1981) in the Colorado, Yampa, Crystal, Roaring Fork, Frying Pan, and Homestake rivers in western Colorado (Walsh and others 1980), rivers in New Mexico (Ward and Lukenn 1984), and in Utah (Narayanan and others 1983). Other studies have estimated the recreation use value of the Colorado River at Westwater Canyon (Bowes and Loomis 1980) and of rivers in Arizona (Gum and Martin 1975; King and Walka 1980), in Idaho (Michaelson 1977; Brooks 1979), in Wisconsin (Boyle and Bishop 1984), and in the United States (Vaughan and Russell 1982). While the present study is concerned with the value of river recreation use, it differs from earlier work by introducing public nonuse preservation values to the evaluation of potential wild and scenic rivers.

The purpose of this study is to measure the preservation value of rivers to the general population, including: (1) option value, a kind of insurance premium to guarantee the opportunity to choose to visit rivers in the future; (2) existence value, the satisfaction from knowing that rivers exist as a natural habitat for fish, plants, wildlife, etc.; and (3) bequest value, the satisfaction from endowing future generations with rivers.

METHODOLOGY

The direct interview or survey approach used in this study was recently recommended as providing an acceptable measure of the economic value of recreation opportunities and resources. An interagency committee of the U.S. government (Water Resources Council 1979, 1983) authorized use of the contingent valuation method and established procedures for its application to outdoor recreation and environmental quality problems. The approach is based on the intentions of a cross-section of the affected population to pay, contingent on hypothetical changes depicted in photos, maps, and narrative description. The approach has been successfully applied to a number of recreation valuation problems since its initial proposal by Davis (1963).

The basic data were obtained from a mail survey of 214 resident Colorado households during the first quarter of 1983. Sample size was determined by standard practice to obtain statistically significant results and was consistent with the Water Resources Council guidelines which recommend a minimum of 200 interviews. Response rate was 51 percent to three mailings. The characteristics of the sample were very similar to the population of the state, closely approximating income level and income distribution, age of household head, household size, occupations and education. A random sub-sample of 10 percent of the nonrespondents were contacted by phone. A substantial majority of the subsample favored river protection and only 14 percent opposed it. Thus nonresponse cannot be equated to lack of interest or value from river protection. A number of additional tests were performed to evaluate the validity of the values reported, with generally satisfactory results.

Respondents were asked to make a series of five budget allocation decisions based on total annual benefits received from increments in river protection, i.e., to write down the maximum amount of money they would be willing to pay annually for hypothetical increases in the number of rivers protected as depicted on a map of the state. Once this budget allocation question was completed, they were asked to allocate the highest amount reported among the four categories of value: recreation use, option, existence, and bequest demands. Preservation benefits are the residual after recreation use benefits have been subtracted from the total willingness to pay. Allocating preservation benefits into the three major categories of motivation in public goods consumption facilitates analysis of their separate association with river protection, as will be illustrated later.

SURVEY RESULTS

Nearly all of the households surveyed favor protection of the 11 study rivers. The most important river is the Cache la Poudre, with 78.5 percent reporting that they favor or strongly favor its protection as a wild and scenic river. The preference for protection of other study rivers is not significantly lower than for the Poudre. The second most important river is the Gunnison, preferred by 75.6 percent of the households. This is followed, in declining order of preference, by the Colorado (75.0 percent), Green (74.7 percent), Yampa (73.1 percent), Elk (72.0 percent), Dolores (72.1 percent), Piedra (71.5 percent), Los Pinos (69.4 percent), Encampment (69.3 percent), and Conejos (65.1 percent).

A substantial majority of the households surveyed favor the study of additional rivers in the state. The most important additional river is the Arkansas, with 61.1 percent reporting that they favor or strongly favor its study for possible protection. The second most important additional river is the Roaring Fork, preferred by 59.5 percent of the households. This is followed, in declining order of preference, by the Yampa (58.6 percent), South Platte (56.9 percent), Rio Grande (54.9 percent), an additional 95 miles of the Dolores (54.8 percent), and the Crystal (43.9 percent). Several respondents suggested that St. Vrain, Eagle, and White rivers also should be studied for possible protection.

The people of Colorado value the multiple purpose of rivers. The most important reason reported for valuing rivers was to protect the quality of water, air and scenery. The next most important reason was the satisfaction from knowing that future generations will have rivers. Third in importance was the protection of fish and wildlife habitat. Satisfaction from knowing they have the option of <u>possible</u> recreation visits to rivers in the future was the fourth most important reason. These preservation values ranked higher than the opportunity for <u>actual</u> recreation use of rivers for fishing, boating, camping, hunting, sightseeing, etc., which ranked fifth in importance. The final reason was the satisfaction

from knowing that rivers exist and are protected. However, 70.5 percent of the households rated knowing that rivers are protected as important or very important. These results suggest that rivers provide many nonuse preservation benefits to the people of the state in addition to actual recreation use benefits. In fact, preservation motivations appear to be more important than recreation.

Recreation use of the 11 study rivers is expected to increase from 1.7 million visitor days in 1983 to 2.3 million in 1990. This represents a 37 percent increase in seven years, equal to a compound annual growth rate of 4.6 percent a year. Growth in recreation use of the 11 study rivers is expected to be more than double the 2.0 percent annual growth in forest recreation forecast based on the 1977 national survey of outdoor recreation. The recreation use of several of the study rivers is constrained by carrying capacity standards, related to their location and site characteristics, including the amount of useable area. The recreation use of rivers will eventually be constrained by their ability to physically accept some level of human activity and still retain the quality required by designation and expected by society.

Substantially more of the visitors to study rivers than to other rivers engage in the activities of sightseeing, picnicking, fishing (particularly fly and lure fishing), photography, hiking, camping, and driving off-road vehicles. This reflects the attractiveness of the outstanding scenic quality of the study rivers. It is significant that sightseeing is the primary activity at study rivers. However, we should not ignore the fact that it also ranks among the primary activities at other rivers. Several of the study rivers provide outstanding whitewater boating opportunities (Colorado, Dolores, Green, Poudre, and Yampa rivers). However, the same is true for several other rivers in the state. The households reported they are somewhat less likely to go rafting, canoeing, or kayaking at the study rivers than at other rivers in the state.

Table 1 shows that the present value of social benefits from protection of the three most valuable rivers in the state (Cache la Poudre, Elk, and Colorado) is estimated as $599 million, including about $113 million recreation use value and $486 million nonuse preservation value.[1] With designation of additional rivers, the present value of benefits increases at a decreasing rate. Present value of benefits rises to $1,119 million with designation of the seven most valued rivers, and to $1,430 million with designation of all 11 study rivers. The present value of benefits is forecast to rise to a maximum of about $1,521 million with designation of 15 rivers, including four rivers not yet studied. The most preferred additional study rivers are the Arkansas, Roaring Fork, South Platte, and Rio Grande rivers.

Benefit cost analysis instructs the decision maker to continue increasing the number of wild and scenic rivers until the excess of benefits over costs is as large as possible. The benefits of river protection will be at a maximum where willingness to pay for an additional river equals its opportunity cost. This optimum point occurs at about 14.5 rivers with the marginal costs of management and the opportunity costs of foregone timber, minerals, and grazing (see figure 1). The optimum occurs at about 13.7 rivers when marginal costs include these amounts and an estimate of the opportunity costs of possible water development projects on the Elk and Gunnison rivers. This is the optimum point at which river protection should be set, if maximum economic welfare is to be achieved. If river protection is less than this amount, some potential benefits would not be realized. Protecting rivers beyond this point would result in larger costs than the benefits they produce.

The optimum number of wild and scenic rivers is not very sensitive to variations in the level of marginal costs. Marginal benefits of designating the 11 study rivers are $42 million, 8.75 times the level of marginal costs, $4.8 million. However, including nonuse preservation values along with the consumer surplus of recreation use in the total benefit function has a substantial effect on this relationship. Without preservation values, the marginal benefits from recreation use of the 11 study rivers decline to $8 million, with a 95 percent confidence interval of $6 to $10 million. While the lower bound of this confidence interval is more than the $4.8 million present value of marginal costs, an underestimation of marginal costs could result in an unfavorable benefit cost ratio.

DISCUSSION OF RESULTS

Ordinary least squares regression techniques and tests of significance were applied in analysis of the data. Household benefit functions were related to several important variables, including: reasons rivers are valued, trips to visit potential wild and scenic rivers, importance of various types of river recreation experience, and social economic characteristics of the households. Several important patterns are indicated.

First, the more experience individuals have in river recreation, the more familiar they are with the characteristics of rivers, and this appreciation contributes to willingness to pay for preservation values, particularly for option and existence demands.

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[1] Present value is the sum of the discounted benefits received each year for the fifty year planning period considered in this study. As such it is the investment value of wild and scenic rivers, which is the amount that a prudent government could afford to invest in wild and scenic rivers if there were no costs. In benefit cost analysis, it is the numerator in the benefit/cost ratio. A planning period of fifty years and an interest rate of 7.875 were selected to conform with Federal procedures currently used in estimating benefits and costs of public water projects (U.S. Water Resources Council 1983).

Table 1.--Present value of total and marginal benefits and costs for increments in Wild and Scenic River designation, Colorado, 1983

Present Values[a] (Million Dollars)	Potential Wild and Scenic Rivers			
	Three Most Valuable Rivers (Poudre, Elk, and Colorado)	Seven Most Valuable Rivers (Add Gunnison, Green, Yampa and Piedra)	Eleven Study Rivers (Add Los Pinos, Conejos, Dolores, and Encampment)	Fifteen Most Valuable Rivers[b] (Add Arkansas, Roaring Fork, South Platte, & Rio Grande)
Total Recreation Use Value and Preservation Value to Colorado Households	$598.8	$1,118.8	$1,429.8	$1,521.1
Recreation Use Value	113.0	212.1	270.5	286.7
Preservation Value	485.8	906.7	1,159.3	1,234.4
Option Value	94.6	176.5	226.0	240.3
Existence Value	170.2	317.5	406.3	433.5
Bequest Value	221.0	412.7	527.0	560.6
Average Value Per River	199.4	160.7	130.0	101.4
Marginal Value Per River[b]	131.6	86.9	42.2	0
Total Costs of Management and Opportunity Costs[c]	10.5	17.9	27.7	39.9
Marginal Costs Per River	1.6	2.1	2.7	3.4
Total Costs with Two Water Projects[d]	31.8	48.3	57.9	100.0
Marginal Costs with Two Water Projects[e]	8.2	1.6	4.8	17.9

[a] With a fifty-year planning period and the 7.875 percent federal rate of discount for fiscal 1982-83 (U.S. Water Resources Council 1983).

[b] Marginal benefits are the first derivative of the aggregate benefit function: $MB = 165.46 - 11.18Q$.

[c] Management costs included investment costs of initial construction, planning, and purchase of physical and scenic easements, plus annual operation and maintenance costs. Opportunity costs included estimates from the wild and scenic river environmental impact statements regarding the loss of timber, minerals and grazing.

[d] Opportunity costs were augmented with estimated net disbenefits from two water development projects that could possibly be constructed without designation. They are on the Elk ($16.7 million) and the Gunnison ($12.9 million) rivers.

[e] Marginal costs are the first derivative of the total cost function: $MC = 19.66 - 4.75Q + 0.31Q^2$ $R^2 = .96$ $F = 85.6$ Cases = 11 where Q = number of rivers, and all coefficients are significant at the .05 level.

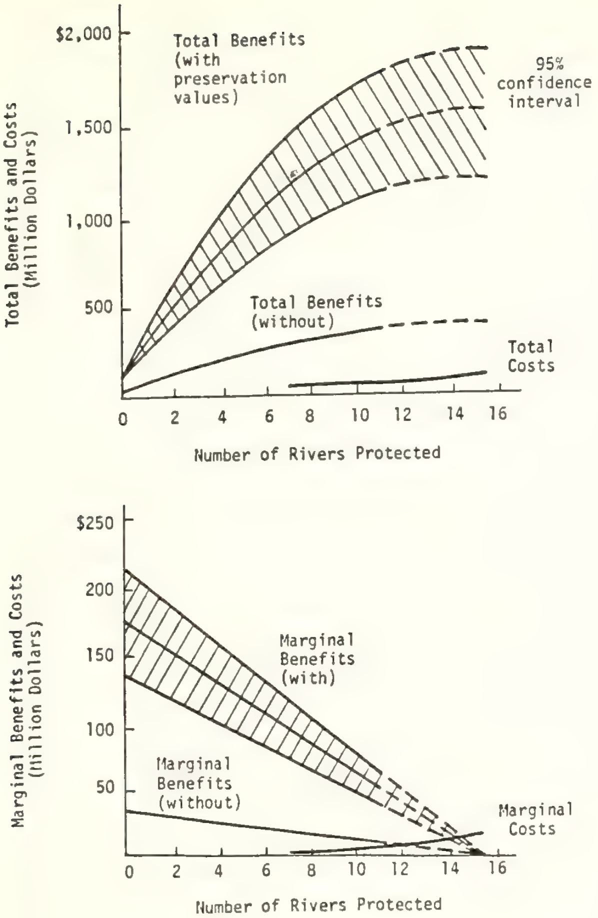

Figure 1.--Present value of total and marginal benefits and costs for increments in Wild and Scenic River designation, Colorado, 1983.

Second, members of agricultural organizations, often considered the foes of river protection, are willing to pay more for preservation value, and for option, existence, and bequest values, than other citizens of the state.

Third, members of environmental groups, often the advocates of river protection, were willing to pay more for option value and bequest value, but not for existence value and recreation use value. Thus, the existence and recreation use demands of environmentalists are not significantly different from the general population.

Fourth, household income had a positive effect on option and bequest values, but a negative effect on recreation use and existence values. For total preservation value, the income effect was slightly negative. However, the income variable was not statistically significant in any of the functions, which suggests that the value of rivers to the citizens of the state is not constrained by income levels.

Fifth, education was positively associated with recreation use value, option values, and total preservation values; but was not a significant variable explaining existence and bequest values. These results suggest that citizens from all education levels were willing to pay for the existence value of wild and scenic rivers, and their bequest to future generations. Sixth, managers and professionals were willing to pay more in every case than citizens in other occupations. Also, workers (skilled, unskilled, sales and clerical) were willing to pay more for recreation use and existence values. This suggests that the value of wild and scenic rivers is broad-based, and crosses most occupational categories. Seventh, both men and women are equally willing to pay for the preservation values of wild and scenic rivers. Men are willing to pay more for the recreation use of study rivers which reflects the fact that men are more likely to participate in most recreation activities at rivers.

Eighth, an index of the quality of the study rivers is positively associated with willingness to pay in all cases. Since the quality index was developed from the criteria used by government agencies in studies of the quality of rivers, the findings support the reasonableness of their work. Indications are that the river values of citizens of Colorado are statistically associated with the valuation criteria used by the study teams. What they lacked was a standard measurement process; the index variable may be a step in that direction.

CONCLUSIONS

The present value estimates of benefits are likely to prove conservative because they are premised on the assumption that real (after inflation) dollar benefits per household will not increase in the future. This may be a reasonable forecast of recreation use and preservation benefits from wild and scenic rivers in the foreseeable future for an economy beset with energy shortages, high prices, and near stable real incomes. However, Fisher and others (1972) and Smith (1972) have demonstrated that the real benefits from preservation of wild and scenic rivers would rise over time compared to benefits from alternative uses of these resources. This is due to the fixed supply of natural environments and the effect of technological change which increases productivity and introduces substitutes for goods produced from natural resources.

Population is expected to continue to grow rapidly in Colorado and other western states, as migration from other parts of the nation continues to occur. Moreover, statistical analysis suggests that future growth in income, increased education levels, and change in the age characteristics of the population will increase willingness to pay for recreation use and preservation value of additional wild and scenic rivers. Substitute recreation areas will become more crowded, and with more leisure time available the proportion of the population who engage in recreation activities at rivers in the state will increase. Recreation use of the 11 study rivers is expected to grow at an average annual rate of 4.6 percent compared to 2.0 percent expected at other Forest Service administered recreation areas.

The preservation value estimates omit nonresidents of the state who are expected to have some positive preservation values for Colorado wild and scenic rivers, although much less than in-state residents. However, given the large number of households who are expected to have positive values, even a low value would result in substantial aggregate nonresident values for Colorado wild and scenic rivers.

In addition to the economic measures of the recreation use and preservation value of wild and scenic rivers, there may be long-run ecological values that are not included here. It is difficult for biologists to predict what these might be, let alone measure them and incorporate them into an economic benefit estimate. For this reason, it seems that the present economic value of wild and scenic rivers represents a conservative estimate of the total value of protection to society. The inability of economics to place a dollar value on unknown ecological effects should be recognized in making decisions about future wild and scenic river designation.

REFERENCES

Bowes, Michael D., and Loomis, John B. A note on the use of travel cost models with unequal zonal populations. Land Economics 56(Nov.): 465-70, 1980.

Boyle, K. J., and Bishop, R. C. Economic benefits associated with boating and canoeing on the Lower Wisconsin River. Economic Issues No. 84, Dept. of Agricultural Economics, University of Wisconsin, Madison, 1984.

Brooks, R. O. The economic impacts of the Wild and Scenic Rivers Act on the Middle Fork of the Clearwater River. Masters thesis, University of Idaho, Moscow, 1979.

Daubert, John T., and Young, Robert A. Recreational demands for maintaining instream flows. American Journal of Agricultural Economics 63(Nov.):667-76, 1981.

Davis, Robert K. Recreation planning as an economic problem. Natural Resources Journal 3 (Oct.):239-49, 1963.

Fisher, Anthony C., Krutilla, John V., and Cicchetti, Charles J. The economics of environmental preservation: a theoretical and empirical analysis. American Economic Review 62(Sep.):605-19, 1972.

Gum, Russell L., and Martin, William E. Problems and solutions in estimating the demand for and value of rural outdoor recreation. American Journal of Agricultural Economics 57 (Nov.): 558-66, 1975.

Hammock, J., and Brown, G. Waterfowl and wetlands: toward a bioeconomic analysis. Johns Hopkins University Press, Baltimore, 1974.

King, David, and Walka, Ann. A market analysis of trout fishing on Fort Apache Indian Reservoir. School of Renewable Natural Resources, University of Arizona, Tucson, Arizona, 1980.

Krutilla, John V. Conservation reconsidered. American Economic Review 57(Sep.):777-86, 1967.

Michaelson, Edgar. An attempt to quantify the esthetics of wild and scenic rivers in Idaho. in Proceedings of a Symposium on River Recreation Management and Research, General Technical Report NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Serivce, North Central Forest Experiment Station; 1977.

Narayanan, R., Larson, D. T., Bishop, B., and Amirfathi, P. An economic evaluation of benefits and costs of maintaining instream flow, Proj. No. B-132-Utah, Utah Water Research Laboratory, Utah State University, Logan, 1982.

Smith, V. Kerry. The effect of technological change on different uses of environmental resources. in Natural Environments: Studies of Theoretical and Applied Analysis, edited by John Krutilla, Johns Hopkins University Press, Baltimore, 1972.

U.S. Dept. of Agriculture. Cache la Poudre wild and scenic river final report (Forest Service, Washington, D.C.), 1982.

U.S. Water Resources Council. Procedures for evaluation of National Economic Development (NED) benefits and costs in water resources planning. Federal Register 44:242(Dec.):72, 950-65, 1979.

U.S. Water Resources Council. Economic and environmental principles and guidelines for water and related land resources implementation studies. Washington, D.C., 1983.

Vaughan, William J., and Russell, Clifford S. The value of a fishing day: an application of a systematic varying parameter model. Land Economics 58(Nov.):450-63, 1982.

Walsh, R. G., Ericson, R. K. Arosteguy, D. J., and Hansen, M. P. An empirical application of a model for estimating the recreation value of instream flow. Completion Report No. 101, Colorado Water Resource Research Institute, Colorado State University, Fort Collins, 1980.

Walsh, R. G., Sanders, Larry D., and Loomis, J. B. Wild and scenic river economics: recreation use and preservation values, American Wilderness Alliance, Denver, 1985.

Ward, Frank A., and Lukenn, David R. Water appropriations for instream benefits: economic and institutional feasibility. Research Bulletin, Agricultural Experiment Station, New Mexico State University, Las Cruces, 1985. Forthcoming.

Weaver, G. D. Effects of wilderness legislation on water-project development in Colorado. Colorado Water Resources Research Institute, Colorado State University, Fort Collins, 1983.

Weisbrod, Burton. Collective-consumption services of individual-consumption goods. Quarterly Journal of Economics 78(Aug.):471-77, 1964.

Young, R. A., and Gray, S. L. 1972. Economic value of water: concepts and empirical estimates. Final Report to the National Water Commission. National Technical Information Service, U.S. Department of Commerce, 1972.

HOW MUCH WILDERNESS TO PROTECT?

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ABSTRACT: The purpose of this paper is to illustrate a procedure for estimating the preservation value of increments in wilderness protection using the contingent valuation approach recommended by an interagency committee of the U.S. government.

INTRODUCTION

In the past, most states and federal agencies encouraged wilderness designation of unique natural environments. Recently, some observers have begun to question whether the benefits of additional wilderness designation exceed opportunity costs. The people involved are interested in what can be learned from recent experience to help formulate sound wilderness policies for the future. Without information on preservation values to all of the people, insufficient public land may be allocated to wilderness protection in such states as Colorado where future roads, timber, mineral, energy, water, and housing development may irreversibly degrade the natural environment. Governments worldwide face a similar problem of how much natural environment they can afford to protect as wildlife sanctuaries, national parks, and wilderness areas.

Recently, the supply of natural environment has been sharply curtailed in several areas of the United States as a result of bulldozing roads and constructing facilities for timber harvest, energy development, mining, mountain subdivisions, ski areas, and water diversions, with prohibitive cost of rectifying the damage (Kneese and Brown 1981). The imminent possibility of expanded development and the probability of damage to natural environments provides a realistic setting for investigating the empirical significance of wilderness preservation values. If potential development were to result in permanent or long-run loss of a scarce natural environment because of the inability or prohibitively high cost to restore natural conditions, then current and future generations would be denied natural environments. Some types of development may degrade environmental quality for centuries. Under current rules, only publicly owned, roadless areas are considered for possible wilderness designation. While mineral and energy development projects often exhaust themselves unexpectedly early, the quiet successor may be mountain home development (Porter 1982).

The Wilderness Act of 1964 provided that wilderness areas may be established to protect the quality of the natural environment, that is, essentially unmodified with few traces of man. Wilderness designation prohibits such development as buildings, roads, dams, timber cutting, and since 1983, new mining patents. Wilderness areas provide such multiple uses as hiking, horseback riding, camping, fishing, hunting, and other nonmotorized recreation, watershed protection, livestock grazing, and mining, so long as the environment is protected essentially in its natural condition.

The environmental economics literature identifies several possibilities of willingness to pay for the preservation of wilderness resources in addition to the benefits from actual recreation use. We will designate willingness to pay for the bundle of satisfactions as <u>preservation benefits</u> and hypothesize that it is separable into option, existence, and bequest demands, as suggested by Weisbrod (1964) and Krutilla (1967). Option value is defined as the annual payment of a kind of insurance premium to retain the opportunity of future recreation use. Existence value is the willingness to pay for the knowledge that a natural environment is protected by wilderness designation even though no recreation use is contemplated. Bequest value is defined as the willingness to pay for the satisfaction derived from endowing future generations with wilderness resources.

STUDY AREAS

The case considered here is how much wilderness to protect in Colorado. Respondents were shown four maps of the state depicting the current wilderness areas and hypothetical increases in amount. At the time of this study (summer 1980), there were 1.2 million acres in 13 designated wilderness areas, equal to about 2% of the 66 million acres of land in the state. In the closing days of 1980, the U.S. Congress designated 1.4 million acres of additional wilderness in 14 new areas and 7 expansions. Thus, in 1981, there were 2.6 million acres of designated wilderness, equal to 4% of the state. A third map depicted 5.0 million acres, including the original 2.6 million acres plus roadless areas designated for wilderness study. The fourth map showed 10 million

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acres of potential wilderness areas equal to 15% of the state. All of these areas were part of the 36% of the state in public ownership. Included were the 6.5 million acres of U.S. Forest Service roadless areas, 1.3 million acres inventoried by the Bureau of Land Management, 0.5 million acres of the U.S. Park Service, and other public land which may be suitable for designation as wilderness, although rejected in favor of potential water, timber, mineral, energy, ski site, and other development. In the long run, society may place a higher value on protecting the quality of the environment, and areas rejected in the past may be restudied for possible designation.

Most of the study areas are at elevations of 9,000 to 14,000 feet. The Continental Divide passes through the midsection of the state, with massive peaks and deep canyons carrying streams both east and west. The state contains 381 peaks between 11,000 and 14,000 feet and 53 over 14,000 feet. Much of the study area consists of bare rock, and the open landscape provides vistas for many miles. Thin soil and 15-30 inches of rainfall support forest growth below timberline of 11,500 feet. Headwaters of the Colorado, Rio Grande, Arkansas, and Platte rivers originate at alpine lakes with pristine water quality which gradually degrades as elevation diminishes and human encroachment increases. Forests of pine, spruce, fir, and aspen are interspersed with meadows of shrubs, grasses, and wildflowers. Many wildlife species are present, including bald and golden eagles, bighorn sheep, black bear, mountain lion, mule deer, elk, moose, mountain goat, beaver, marten, and other small animals, birds, and fish. The study areas tend to be cool and dry, with summer temperatures seldom rising above 90 degrees Fahrenheit, which is comfortable because of low humidity.

RESEARCH METHODS

The preservation value of wilderness was measured by the contingent valuation method recently approved by the U.S. Water Resources Council (1979, 1983) as providing an acceptable procedure for estimating the economic value of recreational and environmental resources. The interagency committee established procedures for surveying a sample of the affected population about maximum willingness to pay contingent on changes in the availability of an environmental amenity such as wilderness.

A sample of 218 resident Colorado households participated in a mail survey in the summer of 1980. Respondents were asked to make a series of four budget allocation decisions based on total annual benefits received from increments in wilderness designation, i.e., to write down the maximum amount of money they would be willing to pay annually for protection of current wilderness, and for hypothetical increases in wilderness depicted on four maps. Once this budget allocation question was completed, respondents were asked to allocate the highest amount reported among the four categories of value: recreation use, option, existence, and bequest demands.

Thus, recreation users allocated a portion of their total annual willingness to pay for wilderness to (1) consumer surplus from actual recreation use, and to (2) payment of a kind of insurance premium to retain the option of possible future recreation use, in addition to expected consumer surplus. We hypothesize that these represent separate and distinct annual values. Then recreation users and nonusers allocated a portion of the remaining total annual willingness to pay for wilderness to: (3) existence value, the satisfaction from knowing that it exists as a natural habitat for fish, plants, wildlife, etc.; and (4) bequest value, the satisfaction from knowing that wilderness will be protected for future generations. Total preservation benefits are the residual after recreation use benefits have been subtracted from the total willingness to pay for wilderness protection.

The contingent market was designed to be as realistic and credible as possible. An introductory letter described the nature of wilderness and the problem, stating, in part, that: "One of the most important questions we face as citizens of Colorado is how much wilderness to protect." The questions were preceded by a statement that annual payment for wilderness protection would postpone irreversible economic development. This would permit information to become available enabling respondents to make a decision in the future as to which alternative, wilderness or development, would be most beneficial to them. Nonpayment would result in substantial damage to the natural environment. Most residents of the state were aware of damages in several areas as a result of past and ongoing development with prohibitive cost of rectifying the damage. The imminent possibility of expanded development and the probability of substantial damage to the natural environment provided a realistic setting for investigating the empirical significance of preservation values.

The legitimate scientific purpose of the survey was established by use of university letterhead and self-addressed return envelopes. The questions were presented as a hypothetical experiment intended to provide an economic measure of how strongly respondents value wilderness protection. The provision that all Colorado citizens would pay was introduced to minimize the free-rider problem. These procedures were designed to reduce the possibility that individuals would engage in strategic behavior, over- or understatement of true values in an effort to influence the quantity of wilderness protected.

Respondents were asked to report their willingness to pay into a special fund to be used exclusively for the purpose of protecting wilderness. This relatively neutral method of payment is recommended over such alternatives as entrance fee, sales tax, or electric bill, to avoid emotional reaction or protest against the method (Water Resources Council 1979, 1983). The payment vehicle was considered especially suitable because Colorado residents would recognize it as similar to the state income tax form's checkoff

for nongame wildlife preservation. Also, respondents were asked to assume that this method of payment was the only possible way to finance wilderness protection. This constraint was designed to minimize the incidence of zero response as a protest against the method of payment. Respondents not willing to pay for wilderness preservation were asked a series of questions designed to find out why. It was determined that rejection of the payment vehicle or hypothetical market represented 9.7% of the sample, which is within the 15% limit recommended by the Water Resources Council guidelines.

The introductory letter also urged individuals to participate in the study whether they favored or opposed wilderness. This was included to discourage possible self-selection bias in which the decision to respond is a function of the importance of wilderness to the individual (Heckman 1979). The population appears to be fairly represented by the mail survey with a response rate of 41% which may represent the population as well as would a higher response. Characteristics of the sample, with respect to distribution of residence, income, age, education, occupation, and household size, were very close to the general population of Colorado as reported in the 1980 Census.

The open-ended direct question may provide a lower more conservative estimate of value than would the interactive bidding technique. Heads of households were asked to write down their maximum willingness to pay as an open-ended direct question. While both the open-ended and iterative approaches are recommended by the Water Resources Council, the iterative procedure has been preferred, because it is specifically designed to assist respondents as they approach the point of indifference between having the amount of income stated or the environmental amenity. However, open-ended questions in mail surveys may have several advantages. The questions can be answered at home and at a time convenient to the respondent. Household members can engage in extensive discussion before giving a dollar amount. There is no possibility that an interviewer may bias the answers, nor that a starting point or interval bias might be introduced. Moreover, variations of the open-ended question have been used in mail surveys of the contingent valuation of hunting (Hammack and Brown 1974; Bishop and Heberlein 1979; Brookshire and others 1983) and of wilderness recreation (Cicchetti and Smith 1973, 1976).

The validity of values obtained from the mail survey was tested in a recent replication of the study for a subsample of the population of the state (Walsh and others 1985). The study design followed Randall and others (1981) in most respects. The heads of households were personally interviewed in their homes. The open-ended and iterative approaches were compared. Group t-tests showed no significant difference at the .05 level between the mean values reported in the two studies (table 1). This suggests that the research methods produced results consistent with those of more advanced study design.

Table 1.--Comparison of resident household willingness to pay for the preservation value of wilderness designation, Colorado, 1983

Sample and format	Sample size	Option value	Existence value	Bequest value	Total preservation value
Statewide mail survey of resident households					
1980 dollars, actual	195	\$9 (2.4)[c]	\$11 (3.0)	\$11 (3.0)	\$32 (8.4)
1983 dollars, update[a]	195	11 (3.0)	13 (3.5)	14 (3.8)	38 (10.2)
Personal interviews with a subsample of households, 1983[b]					
A Format	67	13 (2.2)	15 (2.5)	18 (3.1)	46 (7.8)
B Format	67	10 (1.8)	11 (2.1)	14 (1.9)	35 (5.8)
Average	134	12 (2.0)	13 (2.3)	16 (2.5)	41 (6.8)

[a]Values for 1980 were updated to the first quarter, 1983, using the GNP implicit price deflator, with values rounded to the nearest dollar.

[b]Format A = incremental values for the state when preceded by incremental values for the northern front range region; format B = aggregate values allocated to each motivation. Allocation of the total value for format A to the motivations of willingness to pay were based on the mean allocations reported by respondents to format B, on the basis that the two subsamples were randomly drawn from the same population and exhibited similar socioeconomic characteristics.

[c]The 95 percent confidence interval equals 2 times the standard error (shown in parenthesis $\pm$ the mean value.

EMPIRICAL RESULTS

Table 2 illustrates the effect of adding preservation values to the consumer surplus of recreation use associated with increments in wilderness designation. An aggregate preservation value function was estimated by inserting the four increments in wilderness designation into the condensed household preservation value equation and multiplying by the number of households in the state (1980 Census). To estimate the aggregate option, existence, and bequest value functions, their sample mean proportions of total preservation value were multiplied by number of households. The aggregate consumer surplus of recreation use was estimated by multiplying average consumer surplus of $14 per day by the number of nonmotorized visitor days at these sites reported by the U.S. Forest Service in 1980.

Adding preservation value to the consumer surplus of recreation use had a substantial effect on the benefit function for wilderness. For example, annual preservation value was $35 million for designation of 10 million acres of potential wilderness in the state. Including preservation value increased by 60% the annual benefit estimate of $58 million based on consumer surplus from recreation use. These results are similar to Meyer's (1974), who used the contingent valuation method to estimate the preservation value of protecting wild and scenic rivers in the Fraser River Basin, British Columbia, Canada. He found that nonuse preservation values of resident households in the upper river basin added 54% to the estimated benefits of salmon fishing in the basin.[1]

The preservation value estimates omit nonresidents of the state who are expected to have some positive preservation values for Colorado wilderness designation, although much less than in-state designation. It is indicative that residents of the state reported they were willing to pay an additional $21 per household annually to protect 125 million acres of wilderness in other states. Extrapolating this sample value to the general population of the United States results in a willingness-to-pay estimate of approximately $1.50 per household annually for protection of 10 million acres of wilderness in Colorado. Given the large number of households involved, even this low value would result in substantial aggregate nonresident values for Colorado wilderness.

[1]Low (1970) employed the contribution of time, money, and services by members of Alaskan conservation organizations in support of the Alaska Lands Bill to estimate willingness to pay for the wilderness option. Members were willing to pay an average of $218 to $846 per year, with the value of time in the lower estimate based on the wage value of services provided and the higher estimate based on income of the donor. It appears that members of special interest groups are willing to pay substantially more for preservation or option demand for wilderness at least in support of a campaign of a few year's duration, than the general public would pay annually in the long run.

Table 2.--Total annual consumer surplus from recreation use and preservation value to Colorado households from increments in wilderness designation, Colorado, 1980

Value Categories	Existing and Potential Wilderness Designation: Wilderness Areas, 1980, 1.2 million acres	Wilderness Areas, 1981, 2.6 million acres	Double 1981 Wilderness Areas, 5 million acres	All Potential Wilderness Areas, 10 million acres
Recreation Use Value				
Per Visitor Day	$ 14.00	$ 14.00	$ 14.00	$ 14.00
Total, million	13.2	21.0	33.1	58.2
Preservation Value to Colorado Residents				
Per Household	$ 13.92	$ 18.75	$ 25.30	$ 31.83
Total, million	15.3	20.6	27.8	35.0
Option Value				
Per Household	4.04	5.44	7.34	9.23
Total, million	4.4	6.0	8.1	10.2
Existence Value				
Per Household	4.87	6.56	8.86	11.14
Total, million	5.4	7.2	9.7	12.3
Request Value				
Per Household	5.01	6.75	9.10	11.46
Total, million	5.5	7.4	10.0	12.5
Total Annual Recreation Use Value and Preservation Value to Colorado Households, million	$ 28.5	$ 41.6	$ 60.9	$ 93.2

The question of how much wilderness to protect is illustrated in figure 1. The upper panel shows the total benefits of wilderness in the state of Colorado compared to the total costs of wilderness protection including management and opportunity costs. The lower panel on the same figure shows the marginal benefits and costs derived from the totals in the upper panel. The marginal curves are simply the changes in value of the total curves resulting from changes in the amount of wilderness protected. They may be more familiar as demand and supply curves, with optimum efficiency occurring where the two intersect, i.e., where supply equals demand.

Figure 1 shows the present value of marginal benefits and costs. The present value of annual benefits and costs was estimated for a planning period of 50 years and a discount rate of 7-3/8% to conform with federal procedures.[2] The present value of the sum of consumer surplus from recreation use and preservation benefits was compared to the present value of the sum of management and opportunity costs of wilderness designation. For example, the expected marginal benefits from adding 1 million acres to the present 2.6 million acres was estimated as $148 per acre, compared with marginal costs of $36 per acre. Without preservation values, marginal benefits from adding 1 million acres would be only $78 per acre, but still more than twice the marginal costs.

Designating additional wilderness would be warranted on grounds of economic efficiency until

[2]The U.S. Forest Service also uses a 4% discount rate. To convert the 7-3/8% discount rate to 4%, multiply present value of benefits and costs by roughly 1.5.

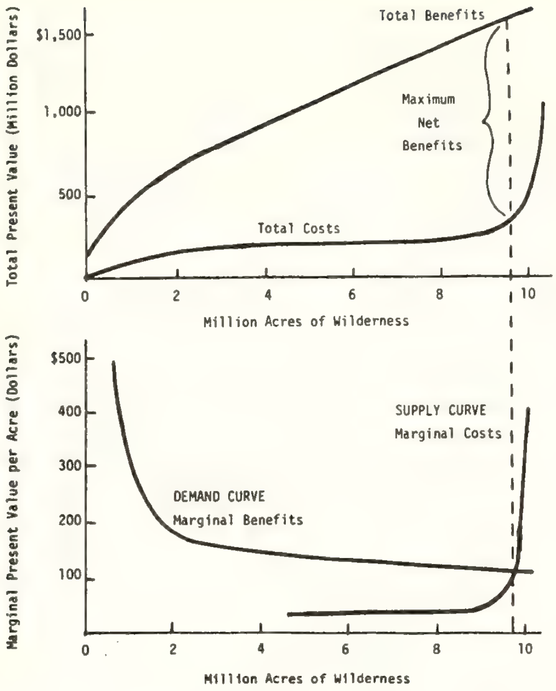

Figure 1.--Present value of total and marginal benefits and costs per acre of wilderness designation in Colorado, 1980.

marginal benefits with preservation values equal marginal costs of $100 per acre at approximately 9.6 million acres. These results are relatively insensitive to changes in the variables because of the extreme flatness of marginal cost over most of its range. Thus, even without preservation values, marginal benefits equal marginal costs of $67 per acre at nearly 9.5 million acres. Even if opportunity costs should double, the optimal amount of wilderness would equal 9.2 million acres with preservation values vs. 7.0 million acres without. The latter is nearly three times the 2.6 million acres currently designated. This relative insensitivity to changes in the variables may be unique to the study area, which has little or no commercial timber value in most roadless areas and excludes a number of sites with known mineral or energy developmental potential.

CONCLUSIONS

This paper addressed the problem of estimating the preservation value of increments in wilderness protection. Specifically, it was shown that preservation demands of resident Colorado households increase at a decreasing rate with added designation. For the first million acres, individual willingness to pay is high because of scarcity value, and the cost is low because of few alternative uses such as timber harvest or mineral and energy extraction. With further increases in wilderness protected, the willingness to pay for an additional million acres decreases, while the additional opportunity costs of alternative uses rise. As individual demands for wilderness are fully satisfied, the shape of the total benefits curve flattens out. Less suitable sites are protected and the opportunity costs of alternative uses rise. The total benefits of wilderness protection are at a maximum where marginal willingness to pay equals marginal cost. This is the point at which wilderness designation should be set, if economic reasoning is followed. If wilderness protection is less than this amount, some potential benefits would not be realized. Designation of wilderness beyond this point would result in larger costs than the benefits they produce.

There are two points that should be made about this approach to the allocation of environmental resources (Freeman 1979). First, the amount of wilderness designated by this rule will almost never equal all of the potential wilderness area. As the best wilderness areas are designated, the willingness to pay for additional wilderness designation will decrease, while the extra cost of further designation will be increasing. The extra cost of going from designation of 95 percent to 100 percent of potential wilderness areas may be several times larger than the total cost of obtaining the first 95 percent. It will seldom be worth it in terms of willingness to pay, as our study shows.

The second point is that benefit cost analysis does not require that citizens who benefit pay for those benefits or that individuals who ultimately bear the cost of wilderness designation be compensated for those costs. It is true that if the amount of wilderness designation is set so as to maximize net benefits, then the gainers could fully compensate the losers and still come out ahead. But when beneficiaries do not compensate losers, there is a serious political problem. Those who benefit call for ever-more wilderness designation, because they obtain the gross benefits and bear none of the costs. Meanwhile, those who bear the cost in the form of foregone profits from timber harvest or mineral and energy development call for less wilderness designation.

The study results provide an empirical test and confirmation of the proposals by Weisbrod and Krutilla that the general population may be willing to pay for the preservation of unique natural environments and that their option, existence, and bequest values should be added to the consumer surplus of recreation use to determine the total economic value of wilderness to society. The values reported should be considered first approximations to be verified or modified by further research. The estimates are sufficient, nonetheless, to demonstrate that estimating the preservation value of increments in wilderness designation would represent a substantial contribution to the present value of benefits estimated by the travel cost method. In the absence of information on the willingness to pay for preservation values, insufficient public land would be allocated to wilderness protection in such states as Colorado, where future mineral, energy, and other development may irreversibly degrade natural environments. Thus, it is proposed that the benefit estimation procedures of federal agencies be enlarged to consider preservation values.

Further research is recommended to test the general application of the approach to analysis of the preservation values of the population of the western region and United States.

This paper has addressed one of the more difficult problems in wilderness management, how to assign a value to outputs that are not exchanged in a market. We have shown that a portion of the benefits of the program are related to recreation use and a portion to the preservation values of the general public. There is a need for further research to measure the proportion of wilderness management and opportunity costs which are attributable separately to recreation use and to protection of the natural resource. State and federal resource management agencies develop policies to allocate limited wildland resources among users and to recoup part of the cost. Thus, appropriate valuation of wilderness resources is critical to decisions about how users and the general public should share in the costs of protection. This paper has illustrated a practical way to develop empirical estimates of the benefits of wilderness programs to users and the general population. The method should be acceptable and the results of this pilot study useful in future research designed to assist actual policy making by public decision makers.

REFERENCES

Bishop, Richard C., and Heberlein, Thomas A. Measuring values of extra-market goods: are indirect measures biased? American Journal of Agricultural Economics 61(Dec.):926-30, 1979.

Brookshire, David S., Randall, Allan, and Stoll, John. Valuing increments and decrements in natural resource service flows. American Journal of Agricultural Economics 63(Aug.): 165-77, 1980.

Brookshire, David S., Eubanks, Larry S., and Randall, Allan. Estimating option prices and existence values for wildlife resources. Land Economics 59(Feb.):1-15, 1983.

Cicchetti, Charles, and Smith, V. Kerry. Congestion, quality deterioration, and optimal use: wilderness recreation in the Spanish Peaks Primitive Area. Social Science Research 2(Mar.):15-31, 1973.

Cicchetti, Charles, and Smith, V. Kerry. The cost of congestion. Cambridge, Mass.: Ballinger Publishing Co., 1976.

Dillman, Donald A. Mail and telephone surveys. New York: John Wiley and Sons, 1978.

Freeman, A. Myrick, III. The benefits of environmental improvement. Baltimore: The Johns Hopkins University Press, 1979.

Gillman, Richard A. Colorado wilderness economics: preservation and use values. Unpublished master's thesis, Colorado State University, Fort Collins, 1981.

Guildin, R. Wilderness costs in New England. Journal of Forestry 78(Sept.):548-52, 1980.

Hammock, J. and G. M. Brown. Waterfowl and wetlands: toward a bioeconomic analysis. Johns Hopkins University Press, Baltimore, 1974.

Heckman, J. J. Sample selection bias as a specification error. Econometrica 47(Jan.):153-61, 1979.

Jungst, Steven. Projecting future use of the national forest wilderness system. Ph.D. dissertation, Iowa State University, Ames, 1978.

Kneese, Allen, V., and Brown, F. Lee. The Southwest under stress: national resource development issues in a regional setting. Baltimore: The Johns Hopkins University Press, 1981.

Krutilla, John V. Conservation reconsidered. American Economic Review 57(Sept.):777-86, 1967.

Low, Christopher, R. The option value for Alaskan wilderness. Ph.D. dissertation. The University of California, Los Angeles, 1979.

Meyer, Phillip A. Recreation and preservation values associated with salmon of the Fraser River. Environment Canada Fisheries and Marine Service, Information Report Series No. PAC/IN-74-1, Southern Operations Branch, Pacific Region, Vancouver, B.C., Canada, 1974.

Milton, William J. National forest roadless and undeveloped areas: develop or preserve. Land Economics 51(May):139-43, 1975.

Outdoor Recreation Resources Review Commission. Wilderness and recreation: a report on resources, values and problems, Study Report 3. Washington, D.C.: U.S. Government Printing Office, 1962.

Porter, Richard C. The new approach to wilderness preservation through benefit-cost analysis. Journal of Environmental Economics and Management 9(Mar.):59-80, 1982.

Randall, A., Hoehn, J. P., and Tolley, G. S. The structure of contingent markets: some results of a recent experiment. Paper presented at the Annual Meeting of the American Economic Association, Washington, D.C. December, 1981.

Smith, V. Kerry, and Kopp, Raymond J. The spatial limits of the travel cost recreation demand model. Land Economics 56(Feb.):60-74, 1980.

Smith, V. Kerry. Option values: a conceptual overview. Southern Economic Journal 49(Jan.): 654-68, 1983.

U.S. Department of Agriculture. Colorado State supplement to roadless area review and evaluation (RARE II). Forest Service, Washington, D.C., 1978.

U.S. Water Resources Council. Procedures for evaluation of National Economic Development (NED) benefits and costs in water resources planning. Federal Register 44:242(Dec. 14): 950-65, 1979.

U.S. Water Resources Council. Economic and environmental principles and guidelines for water and related land resources implementation studies. U.S. Government Printing Office, Washington, D.C., 1983.

Walsh, Richard G., Gillman, Richard A., and Loomis, John B. Wilderness resource economics: recreation use and preservation values. Denver, Colo.: American Wilderness Alliance, 1982.

Walsh, Richard G., and Gilliam, Lynde O. Benefits of wilderness expansion with excess demand for Indian Peaks. Western Journal of Agricultural Economics 7(July): 1-12, 1982.

Walsh, Richard G., Loomis, John B., and Gillman, Richard S. Valuing option, existence and bequest demand for wilderness. Land Economics 60(Feb.):14-29, 1984.

Walsh, Richard G., Bjonback, R. Derek, Rosenthal, Donald H., and Aiken, Richard A. Public benefits of wilderness protection in Colorado. Forthcoming, Department of Agricultural and Natural Resource Economics, Colorado State University, Fort Collins, 1985.

Weisbrod, Burton. Collective-consumption services of individual-consumption goods. Quarterly Journal of Economics 78(Aug.):471-77, 1964.

Wellman, J. D., Hawk, E. G., Roggenbuck, J. W., and Buhyoff, G. J. Mailed questionnaire surveys and the reluctant respondent: an empirical examination of differences between early and late respondents. Journal of Leisure Research 12(2):164-73, 1980.

Wetzstein, Michael E., Green, Richard G., and Elsner, Gary H. Estimation of wilderness use functions for California: an analysis of covariance approach. Journal of Leisure Research 14(1):16-26, 1982.

WILDERNESS EDUCATION AT NOLS: STUDENT OUTCOMES AND CORRELATES OF PERCEIVED INSTRUCTOR EFFECTIVENESS

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ABSTRACT: The objectives of the research reported here were to determine what the graduates of a standard 5-week National Outdoor Leadership School (NOLS) course perceive to be the principal gains from the course. The students report substantial gains in the outcomes of outdoor skill, self-confidence, and leadership skill. The instructors and the curriculum were the most highly influential course dimensions for all three outcomes. The small group dimension of the NOLS experience was less influential. Students were able to differentiate between the teaching behaviors and personality traits of high-effectiveness instructors and low-effectiveness instructors. Strong relationships were found between both the teaching behavior and personality traits of the instructors and their effectiveness ratings by students. Implications for visitor education programs are presented.

INTRODUCTION

Our wilderness areas may be in jeopardy of being loved to death (Hendee and others 1978; Nash 1982). One of the most-mentioned strategies for dealing with increased use of our wilderness areas, and the accompanying environmental and social impacts, is visitor education (Wagar 1940; Petzoldt 1974; Hendee and others 1978; Nash 1982; Roggenbuck 1984). Perhaps the earliest suggestion for wilderness user education was proposed by Wagar (1940) in his published proposal that the National Park Service and the U.S. Forest Service conduct a program to certify outdoorsmen. Included in the proposed program for certification was education on how to "respect and gently live on the land" (Hendee and others 1978).

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While Wagar's proposal was not acted on by either agency, the National Outdoor Leadership School (NOLS), a nonprofit educational institution, was established in 1965 to develop and teach wilderness skills and techniques. NOLS was founded by Paul Petzoldt who developed a mission statement for the new school that seems to have evolved from and begun to put into place Wagar's suggestions. The mission statements of the School are threefold: (1) to develop and teach wilderness skills and techniques, (2) to develop and teach wilderness use that encourages minimum environmental impact, and (3) to develop and teach outdoor leaders. Currently NOLS provides educational programs on public lands to over 1,700 students annually, primarily near its headquarters in Lander, WY, but also at four branch schools in Alaska, Baja Mexico, the north Cascades in Washington, and Kenya in East Africa.

THE RESEARCH OBJECTIVES

Very little research has been done at NOLS over the past 20 years to see if its objectives are indeed being achieved. The research reported here addressed some of the fundamental issues related to wilderness education at NOLS that have implications for wilderness managers who may wish to develop visitor education programs. The specific objectives of the research program were: (1) to determine what the graduates of a standard 5-week NOLS course perceived to be the principal personal gains from the course; (2) to determine which of three hypothesized dimensions of the NOLS experience contributed to the reported personal gains; (3) to correlate aspects of instructor teaching style and personality to perceived instructor effectiveness.

The instructor was seen to be a significant aspect of the NOLS program as he or she orchestrates both the curriculum elements and the group experiences in a rugged environment. On the basis of three hypothesized student outcomes of outdoor skill, leadership skill, and self-confidence and the course dimensions represented by the instructor, the small group living experience, and the NOLS curriculum, we decided to see if it was possible to determine which course dimension influenced which outcomes, on the basis of student self-report. Also, because of our view of the importance of the instructor, we have made

further efforts to characterize the correlates of instructor effectiveness as well as some aspects of instructor personality.

STUDENT OUTCOMES

In keeping with the stated missions of NOLS, two principal student outcomes were hypothesized to result from a NOLS course. These were outdoor skill (including minimum impact camping techniques), and leadership skill. A third potential outcome, self-confidence, was also hypothesized even though it is not an objective of the NOLS curriculum or courses. This was done because self-confidence has often been reported as a result of other outdoor programs but no empirical evidence existed that it results from a NOLS course.

Self-Confidence

Outward Bound and its many derivative programs based on the educational philosophies of Kurt Hahn stress "challenge and personal growth" as the primary student outcomes of an Outward Bound course. The NOLS approach stresses individual competency in wilderness skills and the development of individual leadership skills. The difference between the two philosophies might be characterized by Outward Bound's view that wilderness is a background for challenge--a force to be reckoned with. The NOLS view could be stated as: "The wilderness is a comfortable place for those who learn the skills." Rugged wilderness environments are not seen as a personal challenge. In this sense NOLS does not advertise personal growth as a course outcome. It does however, recognize that it takes place. According to NOLS (1984): "While a NOLS experience will enhance self-confidence and motivation, this takes place individually and naturally, rather than deliberately as the primary focus of the curriculum." Our study is an effort to provide empirical evidence that this indeed occurs.

Extensive reviews of research evaluating self-concept and outdoor adventure programs indicate many methodological problems in study designs and mixed findings in program outcomes (Shore 1977; Ewert 1982). There seems to be evidence, however, that the stress/challenge approach of Outward Bound can produce significant and enduring changes in a variety of components of self-concept. Support for an increase in self-confidence from outdoor programs can be found in Nye's (1976) work at Outward Bound, Kaplan's (1974) work using subjects from an Outdoor Challenge program, and the early work of Clifford and Clifford (1967) also at Outward Bound. Additional support for the hypothesized increase in self-confidence as a result of a NOLS course can be found in the works of Adams (1969), Bernstein (1972), Heaps and Thorstenson (1974), and Winkie (1976).

Outdoor Skill

The development of specific outdoor skills is a ubiquitous and important part of NOLS and other outdoor programs. However, few research studies have addressed changes in the actual outdoor skill level of participants. Kaplan (1974) published one of the few studies that purported to measure, on the basis of pretest/posttest self-reports, changes in outdoor skills as a result of a wilderness skills program. She found that 7 out of 10 specific activity-based skills, (finding food, rock climbing, ecology, map reading, using compass, knowledge of woods, and setting up camp) changed as a result of a program. No change was reported in first aid skill, outdoor cooking, or fire building. The importance of outdoor skill development at NOLS and the findings from Kaplan's work resulted in the hyothesis that students would report significant gains in outdoor skill as a result of their NOLS course.

Leadership Skills

Leadership development is a principal focus at NOLS and therefore it was hypothesized that students would perceive and report gains in this important outcome. Very little research has been done on the question of leadership skill development as a result of an outdoor program. No objective measures of changes in leadership skill are done at NOLS, but a subjective assessment done as part of the post-course evaluation by instructors indicates that positive changes are perceived to take place in many students. Baker (1975), however, found no changes in leadership behavior as a result of an outdoor skills course at NOLS using a standard instrument, the Leadership Opinion Questionnaire.

DIMENSIONS OF A NOLS COURSE

Three major dimensions of the NOLS experience were considered in this research: the NOLS curriculum, NOLS instructors, and the small group nature of the NOLS experience. While the rugged wilderness environment is also considered as an important part of the experience, the subjects examined in this research were all exposed to generally the same type of wilderness setting and thus it was not considered.

The NOLS Curriculum

NOLS is not a survival school or a stress/challenge program. Instead, the goal of the NOLS program is to develop wilderness competencies, the knowledge necessary to develop skilled outdoor users and leaders. A standardized core curriculum has evolved over the past 20 years to accomplish this goal, and it is a key component of the NOLS experience (Petzoldt 1974, 1984; Simer and Sullivan 1983).

The NOLS courses examined in this research are rigorous, 3- or 5-week expeditions typically in extremely mountainous terrain. The courses characteristically consist of three instructors and 17 students. The educational focus of the course allows the students to learn a wide range of mountaineering and wilderness travel skills, and to take part in various leadership development exercises. The curriculum facilitates educational goals through a comprehensive program providing exposure to the skills and knowledge required for minimum-impact conservation techniques, leadership development, outdoor skills, and expedition dynamics. Elements of the core curriculum are outlined in table 1.

Table 1.--The NOLS curriculum for standard wilderness skills courses (NOLS 1985)

Minimum-impact camping and resource protection:
1) Campsite selection
2) Shelter use
3) Stove use and care
4) Sanitation and waste disposal
5) Wildland ethics
6) Land management and use

Travel techniques:
1) Backpacking and carrying
2) Energy conservation
3) Trail techniques
4) Map-reading and compass use
5) Time control plans
6) Off-trail route finding and navigation
7) River crossings

Outdoor living skills:
1) Cooking and baking
2) Nutrition and rations
3) Fishing techniques and ethics
4) Keeping warm and dry
5) High altitude physiology
6) Equipment care and selection

Safety:
1) Basic first aid
2) Safety and accident protection
3) Hazard evaluation
4) Cold-related injury prevention and treatment
5) Mountain rescue techniques

Environmental awareness:
1) Mountain ecosystems
2) Flora and fauna identification
3) Geology
4) Weather

Expedition dynamics:
1) Leadership
2) Expedition behavior
3) Emergency behaviors

Mountaineering:
1) Bouldering
2) Knots, rope-handling, and systems
3) Signals and belays
4) Rock-climbing techniques
5) Anchors and protection placement
6) Rappeling
7) Climbing ethics
8) Snow travel techniques
9) Avalanche forecasting

Constant themes throughout the course are how to be safe and comfortable in the wilderness and how to utilize minimum-impact traveling and camping skills.

NOLS Instructors

There are three basic requirements to become a NOLS instructor: 1) demonstrate proficiency in a wide range of wilderness skills and teaching techniques; 2) pass the intensive 5-week instructor course; 3) apprentice on at least one NOLS course. Given this training, NOLS (1984, p.3) states that:

> NOLS instructional staff are highly skilled professionals, some of the best in the field. They are chosen for the ability to teach and deal successfully with people, as well as their knowledge and technical expertise.

Iida (1975, p. 232) confirms this when she states that NOLS is considered by many as the finishing school for Outward Bound. Arthur in recent articles in popular outdoor magazines has characterized NOLS instructors as knowledgeable outdoor educators who can communicate their own respect for the wilderness to students and who have the ability to capture teachable moments to create a comfortable atmosphere of learning (Arthur 1982). In a similar article she writes, "If competence and judgment are the two qualities most universally admired about NOLS, then the instructors are perfect examples" (Arthur 1983, p. 47).

The team of instructors on a typical NOLS course have a great deal of responsbiility for the students in their charge. They must constantly evaluate individual student's needs and progress, ensure the safety of both the group members and the environment, and, through organization and administration of the course elements, encourage both cognitive and affective change in the students. Because of their overall responsibilities for organizing and delivering the curriculum elements, NOLS instructors are considered extremely important course influences.

The Small Group Experience

The final dimension of a NOLS course is the small group living experience. Characteristically, the larger group of 17 students is divided into living units of 3 or 4 students. This small group living dimension results in an atmosphere of mutual dependence and provides opportunities for individual student leadership and close student interaction. This experience is deemed important by NOLS for the development of good expedition behavior and leadership skills. Additional small group experiences of a slightly different nature are provided when students are assigned to daily travel groups of

5 or 6 students. Student leadership of these groups is assigned and the groups function with progressive independence from instructors as the course moves throughout the expedition. Initially, an instructor travels with each of the groups until sufficient student leadership has been developed and demonstrated. The instructors then gradually leave the students on their own for the day's travel. These intense small group living and leadership experiences are hypothesized to be significant dimensions of the NOLS course learning experience.

INSTRUCTOR INFLUENCES ON STUDENT OUTCOMES

What makes an effective outdoor leader/ instructor was an important part of our research because we felt that experiences and research at NOLS could have important implications for wilderness management strategies that may involve user education. The instructor is an important element, he or she facilitates the mission objectives of NOLS and development of self-confidence as a reported course outcome.

Effective outdoor teachers may be characterized as caring, sensitive, enthusiastic individuals who have mastered the teaching strategies in a unique academic and experiential program. Kilmer (1976), in a study of self-concept of elementary students due to the classroom environment and teacher influences, concluded that teacher warmth in interpersonal relations has a significant positive influence on students' self-concepts. She also found significant positive relationships between self-concept and the amount of freedom provided by the teachers.

Spaulding (1964) found that there was a positive correlation between a learner's self-concept and the degree to which the teachers were calm, accepting, supportive, and facilitative. His study also noted negative correlations for teacher behaviors that were perceived as dominating, grim, threatening, and sarcastic.

Felker and others (1973), as part of an attempt to evaluate a teacher program of enhancement of self-concept, concluded that teachers are capable of increasing self-concept through various behaviors and personality variables such as enthusiasm. The authors concluded that the enhancement program, as represented by differing teacher behaviors, produced important gains in self-concept, reductions in anxiety, and the treatment groups experienced fewer failures than the control groups.

While attempting to determine teacher personality correlates of overall teaching effectiveness, Isaacson and others (1963) used a factor-analyzed version of the 16 Personality Factor Questionnaire, among other instruments, to conclude that teachers with high levels of enthusiasm, cultural attainment, and emotional stability were characteristic of teachers rated high in overall effectiveness. Individual personality traits that had significant correlations ($p<0.05$) with student ratings of overall teaching ability were maturity, aggressiveness, enthusiasm, conscientiousness, and sensitivity.

A study by Hendy (1975) of the personality traits of Outward Bound instructors also used the 16 Personality Factor Questionnaire. His conclusions indicated that, from a personality trait point-of-view, Outward Bound instructors were reserved, bright, tender-minded, very imaginative, forthright, and experimenting. He also concluded that instructors rated as superior had more enthusiasm, were more forthright, and had higher scores on the imaginative and experimenting scales. These traits were seen to represent important teaching behaviors.

METHODS

This study was part of a more comprehensive research effort that used a Solomon four-group design (Campbell and Stanley 1972) to assess the outcomes of NOLS courses in 1984. Data presented here are based on a post-course evaluation instrument administered to all stduents who completed standard NOLS courses at the Wyoming Branch during the summer of 1984. Thirty-nine courses were posttested resulting in 1,560 usable individual evaluations.

The instrument developed for the post-course evaluation consisted of four sections. Section 1 consisted of 13 questions drawn from a 70-item pool and was designed to measure the following dimensions of instructor effectiveness: (a) teaching skills and methods, (b) course management abilities, and (c) interpersonal skills. Eight of the questions dealt with specific attributes of the dimensions of instruction effectiveness. The remaining five questions were global measures of effectiveness based on the instructor's use of leadership techniques, outdoor technical skills, interpersonal skills, and teaching skills. An overall effectiveness rating was also solicited. Students were asked to rate the degree to which instructors demonstrated or possessed the effectiveness attributes on a scale of 1 (not at all) to 10 (yes, definitely).

The second section asked students to rate, on the basis of observed behavior, 16 personality traits of the instructors using a polar-anchored semantic differential scale with values of 1 to 10 (after Cattell and others 1975). The 16 personality factors and their polar anchors are shown in table 2.

The third section asked the students to rate their perceived gain in personal outcomes of

(1) self-confidence, (2) outdoor skill, and (3) leadership skill on a 10-point scale from 1 (not much gain) to 10 (gained a great deal).

The final section asked the students to rate the importance of (1) the instructor, (2) the small group living experience, and (3) the NOLS curriculum in achieving the reported gains. The ratings for this section were also rated on a 10-point scale from 1 (not very important) to 10 (very important).

Table 2.--Personality rating semantic differential scale from post-course evaluation form (range 1-10)

"This instructor seems to be..."
1) Reserved (1) vs. outgoing (10)
2) Bright (1) vs. dull (10)
3) Affected by feelings (1) vs. emotionally stable (10)
4) Humble (1) vs. assertive (10)
5) Sober (1) vs. enthusiastic (10)
6) Expedient (1) vs. conscientious (10)
7) Shy (1) vs. venturesome (10)
8) Tough-minded (1) vs. tender-minded (10)
9) Trusting (1) vs. suspicious (10)
10) Practical (1) vs. imaginative (10)
11) Unpretentious (1) vs. shrewd (10)
12) Self-assured (1) vs. apprehensive (10)
13) Conservative (1) vs. experimenting (10)
14) Group dependent (1) vs. self-sufficient (10)
15) Undisciplined (1) vs. controlled (10)
16) Relaxed (1) vs. tense (10)

Three pretests of the research instrument using university students in an outdoor skills course resulted in alpha reliability coefficients for section 1 of the instrument that ranged from 0.88 to 0.98. Because of the nature of the scales, reliability coefficients were not calculated on the other three sections of the instrument.

The data collection instrument was administered to the students at NOLS the morning after they returned from 5 weeks in the field. All instruments were administered by the same researcher using the same protocol, and course instructors were not present during the evaluation.

RESULTS

Students rated the degree to which they achieved outcomes of self-confidence, outdoor skill, and leadership skill from a NOLS course on a scale of 1 (not much gain) to 10 (gained a great deal). They appear to believe they received all three outcomes. The mean ratings (n=1,560) reported by the students were outdoor skill (8.50), self-confidence (7.56), and leadership (7.13). For those students who rated one outcome higher than the other two, 67 percent reported outdoor skill, 22 percent reported self-confidence and 11 percent reported leadership skill as the highest personal outcome (table 3).

Table 3.--Reported student outcomes as a result of a NOLS course

Reported outcome	Mean (out of 10)	S.D.	% reporting as highest outcome
Self-confidence	7.56	2.09	22
Outdoor skill	8.50	1.69	67
Leadership skill	7.13	2.22	11

n=1,560

The major course dimensions hypothesized to influence these outcomes were the instructor, the extended small group living experience, and the NOLS curriculum. The importance of these course dimensions was also rated on a 1 to 10 scale. The outcome of outdoor skill when correlated with the three course influences resulted in an R^2 of 0.22, the simple Pearson's r was found to be 0.51 for the curriculum, 0.43 for the instructor, and 0.27 for the small group living experience. The highest R^2 obtained (0.32) was for the outcome of self-confidence, where the instructor, the curriculum, and the small group living experience had Pearson's r values of 0.39, 0.35 and 0.29 respectively. Leadership skill had an R^2 of 0.28 and Pearson correlations with the instructor of r = 0.41, the curriculum of r = 0.42, and the small group living experience of r = 0.34 (table 4).

Table 4.--Influence of NOLS course dimension on reported student outcomes

	Course dimension			
	Instructor	Small Group	Curriculum	
	r=	r=	r=	R^2=
Self-Confidence	.39	.29	.35	.32
Outdoor Skill	.43	.27	.51	.22
Leadership Skill	.41	.34	.42	.28

* all r and R^2 values significant at the 0.0001 level.

Four of the eight items related to wilderness instructor teaching characteristics produced an R^2 of 0.64 when correlated with the overall perceived instructor effectiveness. These factors were: planning and administering experiences, tact and sensitivity, good judgment and decision-making skills, and helping students individually meet their goals (table 5).

Instructor effectiveness was also found to be significantly related (R^2 = 0.51) to the

Table 5.--Correlates of student-rated "Overall Instructor Effectiveness"

Independent variable	r	R^2 as variable added
planning and administering material and experiences effectively	0.65	0.43
demonstrates tact and sensitivity in relation with you	0.61	0.55
shows good judgment and decision-making skills	0.62	0.60
help you individually meet your goals	0.61	0.64

* all r and R values significant at .0001 level.

perceived instructor personality traits of intelligence, emotional stability, enthusiasm, relaxed poise, outgoing nature, and degree of self-control. (table 6).

Table 6.--Personality correlates of "Overall Instructor Effectiveness"

Semantic scale item	B Value*	R^2 as variable added	p<F
Intercept	3.8915		
Bright vs Dull	0.5355	0.34	0.0001
Relaxed vs Tense	-.2297	0.41	0.0002
Affected by Feelings (Y/N)	0.2687	0.45	0.0094
Conserv. vs Experimenting	-.1333	0.47	0.0185
Shy vs Venturesome	0.1074	0.49	0.0031
Trusting vs Suspicious	-.1392	0.52	0.0398

To characterize the student-perceived differences in personality between high-effectiveness instructors and lower-effectiveness instructors, further multivariate analysis was undertaken. The distinction between high overall effectiveness and lower overall effectiveness was based on a median split in the overall effectiveness ratings of the instructors by their students. The median effectiveness rating was 8.88 (out of 10). Therefore, while all instructors tended to receive high ratings, the instructors with average effectiveness ratings below 8.88 were considered the lower effectiveness group. Instructors with ratings equal to or above 8.88 were considered to be in the higher group. Table 7 presents the results of the MANOVA, using the overall effectiveness ratings and the perceived instructor personality traits as rated by the students, done to detect differences between the two effectiveness groups. Table 7 shows that the students did perceive significant differences between high-effectiveness instructors and lower-effectiveness instructors for 14 of the 16 rated traits. After control of Type I experimental-wise error rate, only two factors were not significantly different between the two groups. "Tough-minded vs tender-minded" failed to gain significance, but the higher rated instructors tended to receive higher tender-minded scores. "Conservative vs experimenting" also failed to gain significance, but higher rated instructors were perceived as being more experimenting or liberal.

Table 7.--MANOVA and t-tests of means of instructor effectiveness and student-rated personality traits

MANOVA F (Wilks' Criterion) for instructor effectiveness effect

DF = (17,93) F = 6.93 Prob F > = 0.0001

Variable	Instructor Effectiveness High	Low	p>:t:
Overall effectiveness	9.29	8.33	0.05
Reserved vs outgoing	7.03	6.14	0.05
Bright vs dull	7.65	6.97	0.05
Affected by feeling (y/n)	7.00	6.52	0.05
Humble vs assertive	6.28	5.77	0.05
Sober vs enthusiastic	7.37	6.62	0.05
Expedient vs conscientious	7.62	7.29	0.05
Shy vs venturesome	6.99	6.18	0.05
Tough- vs tender-minded	5.00	4.71	0.05
Trusting vs suspicious	1.89	2.65	ns
Practical vs imaginative	5.16	4.83	0.05
Unpretentious vs shrewd	2.62	2.98	0.05
Self-assured vs apprehensive	1.85	2.64	0.05
Conservative vs experimenting	5.11	4.85	ns
Group-depnt vs slf-suffic't	6.80	6.40	0.05
Undisciplined vs controlled	6.98	6.65	0.05
Relaxed vs tense	1.98	2.75	0.05

DISCUSSION

Our research indicates that, from the students' point of view, they did gain a significant education from a NOLS course. Outdoor skill and leadership, the mission objectives of NOLS, appear to have been met. An additional outcome

of value, self-confidence, was also perceived as a significant outcome. The research reported here also indicates that the three major course dimensions, the instructor team, the NOLS curriculum, and the small-group experiences make unique as well as combined contributions in achieving these student outcomes.

The instructor is most influential in producing changes in perceptions of self-confidence, while the NOLS curriculum is most important in the development of outdoor skills. The instructor and the curriculum are both very influential in producing changes in student-perceived leadership skill. The small group experience is perceived to be the least important dimension of a NOLS course. Our research did not adequately address the issue, but it might be expected that the small group experiences, when compared to large group approaches, would turn out to be an important and ubiquitous aspect of both of the other dimensions. Further work is needed to determine this.

An important implication for wilderness managers may be the clarification of characteristics of effective wilderness instructors above and beyond wilderness skills. The most effective instructors are perceived as being able to plan and administer quality learning experiences, demonstrate tact and skill in interpersonal relations, and identify and address individual student needs. The personality traits, based on student-observed behaviors, of quality wilderness instructors have been identified as intelligence, emotional stability, enthusiasm, a relaxed poise yet outgoing, and the demonstration of self-control.

IMPLICATIONS AND NEED FOR FURTHER RESEARCH

Wilderness managers contemplating an education program as a management strategy may be able to influence educational outcomes by carefully considering both the curriculum elements of such a program and the characteristics of the staff responsible for delivering the program. Further research should be aimed at determining to what degree students received what they said they did through more objective measures of student outcomes. In addition, further efforts should be undertaken to characterize instructor personality and other course influences, such as the influence of outcomes of the wilderness setting and experience. An interesting approach would be to examine the influence of the naturalness and solitude provided by the wilderness environment on various student outcomes.

REFERENCES

Adams, W. D. Survival training: its effect on the self-concept and selected personality factors of emotionally disturbed adolescents. Logan, UT: Utah State University; 1969. 388B p. Ph.D. dissertation.

Arthur, E. The Hamilton course. Outside. 1982 August/September: 62-68.

Arthur, E. NOLS: the competence builders. Backpacker. 1983 July: 46-52.

Baker, E. D. Change in leadership behavior attitudes affected by participation in basic courses at the National Outdoor Leadership School. University Park, PA: Penn State University; 1975. Unpublished master's thesis.

Berstein, A. Wilderness as a therapeutic behavior setting. Therapeutic Recreation Journal. 185 (Fourth Quarter): 160-161; 1972.

Campbell, D. T.; Stanley, J. C. Experimental and quasi-experimental designs for research. Chicago: Rand McNally and Co.; 1972.

Clifford, E.; Clifford M. Self-concept before and after survival training. British Journal of Social and Clinical Psychology. 6: 241-248; 1967.

Ewert, Allen. Outdoor adventures and self-concept: a research analysis. Eugene, OR: Department of Recreation and Park Management, University of Oregon.

Felker, D. W.; Stanwyck, D. J.; Kay, R.S. The effects of a teacher program in self-concept enhancement on pupil's self-concept, anxiety, and intellectual achievement responsibility. The Journal of Educational Research. 66 (10): 443-445; 1973.

Heaps, R. A.; Thorstenson, C. T. Self-concept changes immediately and one year after survival training. Therapeutic Recreation Journal. Second Quarter: 60-63; 1974.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Misc. Pub. No. 1365. U.S. Department of Agriculture, Forest Service; 1978.

Hendee, J. C.; Roggenbuck, J. W. Wilderness-related education as a factor increasing demand for wilderness. Unpublished paper, International Forest Congress Convention; Quebec City, Canada; Aug. 5, 1984.

Hendy, C. M. Outward Bound and personality: 16PF profiles of instructors and ipsative changes in male and female students 16-19 years of age. Dissertation Abstracts International. University of Oregon; 1975. 36 (07), 4352-A. Ph.D. dissertation.

Iida, M. Adventure-oriented programs: a review of research. In: van derSmissen, B., ed. Research Camping and Environmental Education; State College, PA: Penn State, HPER series, 11; 1975: 219-241.

Isaacson, R. L.; McKeachie, W. J.; Muholland, J. E. Correlation of teacher personality variable and student ratings. Journal of Education Psychology. 54(2): 110-117; 1963.

Kaplan, R. Some psychological benefits of an outdoor challenge program. Environment and Behavior. 6(1): 101-116; 1974.

Kilmer, M. V. The effects of classroom environment and teacher influences on student self-concept in ESEA, Title 1 programs. Va. Tech.; 1976. Ph.D. dissertation.

Nash, R. Wilderness and the American mind. 3rd. ed. New Haven, CN; Yale University Press; 1982.

National Outdoor Leadership School. n.d. N.O.L.S. By-laws. Mimeographed.

National Outdoor Leadership School. 1984 Catalog of courses. Lander, WY: 1984.

Nye, R. P. The influence of an Outward Bound program on the self-concept of participants. Dissertation Abstracts International. Temple University; 1967. 37 (01), 142A. Ph.D. Dissertation.

Petzoldt. P. The wilderness handbook. New York: W. W. Norton; 1974.

Petzoldt, P.; Ringholz, R. C. The new wilderness handbook. New York: W. W. Norton; 1984.

Shore, Arnold. Outward bound: a reference volume. Greenwich, Conn: Outward Bound, Inc.; 1977.

Simer, P.; Sullivan, J. The national outdoor leadership school's wilderness guide. New York: Simon and Schuster. 1983.

Sirois, R. Outdoor adventure leaders and personality - a descriptive study of personality traits as measured by the 16 personality factor test. University of Oregon; unpublished master's thesis.

Spaulding, R. L. Achievement, creativity, and self-concept correlates of teacher-pupil transactions in elementary schools. In: Stendler, C. B., ed. Readings in child behavior and development, 2nd ed. rev.. New York: Harcourt, Brace and World, Inc.; 1964: 313-318.

Wagar, J. V. K. Certified outdoorsman. Am. For. 46 (11), 490-422, 524-525; 1940.

SELF-ACTUALIZATION AND WILDERNESS USE: A PANEL STUDY

Robert A. Young and Rick Crandall

ABSTRACT: The concept of self-actualization, as developed by Maslow, represents the positive ideal of mental health. It has been suggested that wilderness use is related to self-actualization. The few empirical tests of this theoretical relationship have found either no correlation or a weak positive correlation between the two variables. However, none of the previous studies has examined the possibility of individual changes in self-actualization with continued wilderness use over a period of time. These studies have either looked at changes resulting from a single wilderness experience or compared wilderness users with nonusers. The purpose of this study is to examine possible changes in self-actualization as related to extended wilderness use. Data were collected in 1979 in the Boundary Waters Canoe Area Wilderness from a sample of users visiting wilderness for the first time. Subjects were surveyed again in 1984. For the 188 panel members who completed the survey in 1984, self-actualization scores were significantly higher in 1984 than in 1979. In comparing the more active users in the panel with less active, self-actualization increased for both groups but significantly more for the active users.

INTRODUCTION

Self-actualization is often mentioned as one of the benefits of wilderness use. For instance, conditions present in a wilderness visit, such as solitude and contact with nature are often expected to facilitate self-actualization. Also, people who are self-actualized often seek wilderness to further their growth. However, a strong empirical relationship between self-actualization and wilderness use has never been established. This paper reports on a study that measured the self-actualization of new wilderness users at the beginning of their wilderness experience and again 5 years later.

The concept of a self-actualizing person, as developed by Maslow (1968, 1970), represents a positive state of mental health. Clinical psychologists often consider this to be an ideal psychological state. A self-actualizing person has been described as one who is developing and utilizing all of his/her unique capabilities and potentials without the inhibitions and emotional difficulties of those who are less self-actualized (Shostrom 1974). A self-actualizing person is fully functioning and lives an enriched life; such a positive state has been described as the goal of leisure (Farina 1974).

Scott (1974) was one of the first to suggest a relationship between self-actualization and wilderness use. His contention is based on a study of well-known men who reported peak experiences while visiting wilderness. Scott speculated that from their lives and writings, these men were self-actualized and used wilderness to further their growth. Only a few researchers have empirically studied the relationship between the two variables. Kaplan (1974), in measuring the self-esteem of members of a wilderness challenge program and a control group, found no difference in the self-esteem scores for the members before and after their wilderness experience. She found, however, higher self-esteem scores for those who selected the program than for those in the control group. Similar results were reported by Lambert and others in 1978. Their results showed no change in self-actualization scores before and after a 1-month wilderness class experience.

In a third study (Young and Crandall 1984), self-actualization scores were compared for wilderness users and nonusers (from a general public sample) and for frequent wilderness users and infrequent users. The results showed that although wilderness users scored significantly higher on a self-actualization scale than nonusers, all differences were very small. There were no differences between users who used wilderness frequently and the less frequent users. Young (1983), in studying selected variables and their relationship to wilderness use, found only a weak relationship between self-actualization and the prediction of who would use wilderness, and self-actualization and the amount of use among users. Leisure-ethic scores and several demographic variables accounted for more variance in the intention to visit wilderness for a general public sample, and in the number of previous visits for a sample of wilderness users.

These studies suggest that those who choose to visit wilderness, either in outdoor survival programs or as a recreational activity, are probably more self-actualized than their peers from the general public. This supports the suggestion of Peterson (1971) that wilderness users are a nonrandom segment of the population. Also, there

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appears to be little difference in self-actualization between individuals who use wilderness frequently or infrequently, or between the same individuals before and after such visits.

All past studies either looked at changes resulting from a single wilderness experience or compared wilderness users with nonusers. None examined the possibility of individual changes in self-actualization with continued wilderness visits over a period of time. This paper reports a 5-year longitudinal study of wilderness users designed to identify and analyze possible changes in self-actualization that may be associated with changes in use. To minimize the possible influence of different past wilderness experiences, users with similar wilderness-use backgrounds were selected for this study.

METHODOLOGY

Initial screening data on past wilderness use were collected in 1978 from "new" users[1] contacted at five selected entry points[2] in the Boundary Waters Canoe Area Wilderness (BWCAW) in northern Minnesota. All of the 366 new wilderness users were included in a panel for continued contact. Since 1979 an annual questionnaire (except in 1980) and follow-up reminder were mailed to each panel member asking about his or her subsequent use of wilderness. Those not responding were then interviewed by telephone. Self-actualization was again measured in 1984.

Instruments.--The Personal Orientation Inventory (POI), developed by Shostrom (1974), is by far the most validated measure of self-actualization. Because of the length and format of the POI, a shortened version was developed to measure self-actualization for an earlier study (Young and Crandall 1984). The current shortened version used 15 questions with an agree-disagree answer format. Self-actualization scores for each user were obtained by summing the responses to the 15 questions. For a discussion of the validity and reliability of the shortened self-actualization scale, see Young and Crandall (1984).

RESULTS AND DISCUSSION

Wilderness use.--Of the 366 panel members contacted in 1978, none was a previous wilderness user. When surveyed 1 year later (1979), only 38 (9.6 percent) had visited any wilderness in the previous 12 months. In the 1981 survey, 91 panel members had visited wilderness in the past 24 months, almost 25 percent of the total panel. The annual average for this 24-month period is 45 users or 12 percent, which is consistent with other 12-month periods in the study.

By 1984 only 8.2 percent of the panel had visited wilderness during the 12-month survey period. These results suggest that for "new" wilderness users, consistent annual use of wilderness is low (Young 1985).

Self-Actualization.--The panel members who had completed the survey in 1984 (n = 188) showed a significant ($p < .001$) increase in their self-actualization scores between 1979 and 1984 (table 1). In 1979, 31 percent of the panel scored 60 or less on the scale, while 15 percent had scores of 70 or higher. In 1984, these percentages had changed to 20 and 31, respectively.

Since wilderness use for the panel was low, the respondents were divided into two groups to analyze the changes in self-actualization. Those respondents who reported more days of wilderness use than the median for the entire panel were placed in one group termed active users. Those panel members with less than the median number of reported days in wilderness were placed in a second group termed inactive users. For these two groups there were no differences in self-actualization scores in 1979 when they were new wilderness users. However, by 1984 the active users had significantly ($p < .05$) higher scores than the inactive users. Only 14 percent of the active users scored 60 or less in 1984, while over 27 percent of the inactive users had the same low scores. Thirty-five percent of the active users had scores of 70 or above as compared with 23 percent of the inactive users (table 1).

Additional analyses of these data reveal that when individual scores were compared, both groups had significantly higher self-actualization scores at the end of the 5-year period. Mean scores for the active users increased from 63.55 to 67.16 ($p < .001$). During the same period, inactive users' scores changed from 61.88 to 64.90 ($p < .01$).

We have found that self-actualization scores for the 5-year study period increased for the panel as a whole. Scores were similar for active and inactive users at the start of the study and increased significantly for both groups. However, scores increased more for the active users. After 5 years, the active users had significantly higher scores than the inactive users. All of these changes were found with users who, as a group, reported few return trips to wilderness. With more return visits, perhaps greater changes would have occurred.

DISCUSSION

In an earlier paper (Young and Crandall 1984), the authors discussed five possible relationships between self-actualization and wilderness use.

[1]A new user was defined as a person making his or her first visit to a wilderness area 12 months or less prior to being screened in the summer of 1978.

[2]The entry points used in the study were: Fall Lake, Moose Lake, Lake One, Kawishiwi Lake, and Sawbill Lake.

Table 1.--Self-actualization scores of the BWCAW panel, active and inactive users, 1979 and 1984

User group	N	Mean score	Std. dev.	d.f.	t-value	2-tailed probability
Entire Panel						
1979	148	62.99	7.12			
				147	-5.72	.000
1984	148	66.40	6.98		(paired)	
1979						
Active Users[1]	98	63.55	6.04			
				205	0.51	.611
Inactive Users[2]	110	63.09	6.98			
1984						
Active Users	124	67.56	6.40			
				104	2.09	.04
Inactive Users	62	65.19	7.71			
Active Users						
1979	98	63.55	6.04			
				97	-5.13	.000
1984	98	67.16	6.62		(paired)	
Inactive Users						
1979	50	61.88	8.84			
				49	-2.73	.009
1984	50	64.90	7.49		(paired)	

[1]Wilderness users with more than the median number of reported days in wilderness during the study period.

[2]Wilderness users with less than the median number of reported days in wilderness during the study period.

These are:

1. Wilderness use may cause increases in self-actualization either directly or through moderating variables.
2. Self-actualization may cause wilderness use either directly or through moderating variables.
3. There may be no relationship between wilderness use and self-actualization.
4. Other variables may cause both wilderness use and self-actualization.
5. Wilderness use and self-actualization may exert reciprocal causation. That is, each may encourage the other and in turn be encouraged by it.

Past research, which suggests that people who select wilderness as a form of recreation or for outdoor survival programs are more self-actualized than nonusers, tends to support the second possible relationship, that self-actualization may cause wilderness use either directly or through moderating variables. It is not to imply that all highly self-actualized people use wilderness; other forms of leisure activities are no doubt used by other self-actualized persons.

Our study tends to add support to the first possible relationship, that wilderness use may cause increases in self-actualization either directly or through moderating variables. Respondents who actively used wilderness had significantly higher self-actualization scores at the end of the study than did a group of inactive users. However, in 1979 at the beginning of the study, the two groups did not differ in their self-actualization scores. This suggests that wilderness use may cause increases in self-actualization either directly or through moderating variables (possible relationship 1).

In combination with past research, our study greatly strengthened the case against the third possible relationship, that there is no relationship between the two variables. Nor, can the fourth and fifth possible relationships be ruled out.

Although not conclusive, our study, using longitudinal data, adds support to the theory that suggests a positive relationship between wilderness use and self-actualization.

REFERENCES

Farina, J. Toward a philosophy of leisure. In: Murphy, J. F., ed. Concepts of leisure. Englewood Cliffs, NJ: Prentice-Hall; 1974. 283 p.

Kaplan, R. Some psychological benefits of an outdoor challenge program. Env. and Behav. 16:101-116; 1974.

Lambert, M. J.; Segger, J. F.; Staley, J. S.; Spencer, B.; Nelson, D. Reported self-concept and self-actualization value changes as a function of academic classes with wilderness experience. Perceptual and Motor Skills. 46:1036-1040; 1978.

Maslow, A. Toward a psychology of being. 2nd Ed. Princeton, NJ: Van Nostrand; 1968. 240 p.

Maslow, A. Motivation and personality. 2nd Ed. New York, NY: Harper and Row; 1970. 369 p.

Peterson, G. L. Motivations, perceptions, satisfactions and environmental dispositions of Boundary Waters Canoe Area users and managers. Evanston, IL: Northwestern University, Department of Civil Engineering; 1971. Unnumbered report.

Scott, N. R. Toward a psychology of wilderness experience. Nat. Resource J. 14:231-237; 1974.

Shostrom, E. EITS manual for the personality orientation inventory. San Diego, CA: Educational And Industrial Testing Service; 1974.

Young, R. A.; Crandall, R. Wilderness use and self-actualization. J. Leisure Res. 16:149-160; 1984.

Young, R. A. Toward an understanding of wilderness participation. Leisure Sci. 4:339-357; 1983.

Young, R. A. Trends in wilderness use and attitudes. Paper presented at the Outdoor Recreation Trends II Symposium, Myrtle Beach, SC. Feb. 25-27, 1985.

FACTORS CRITICAL FOR CAMPING SATISFACTION

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ABSTRACT: Eight hundred campers from two campgrounds within the Adirondack Park were systematically sampled and sent mail questionnaires in the fall of 1984. Respondents were asked to rate on a Likert-type scale the importance of and their satisfaction with components of their camping experience. Using the correlations between the importance of each experience component and the correlations of each satisfaction component with overall satisfaction, critical factors were determined. The three critical factors--solitude/rejuvenation, nature, and facility characteristics--had a predictive ability which was modestly lower than that using all factors. By manipulating these factors, managers could produce the greatest change in overall satisfaction.

INTRODUCTION

Satisfactions of wilderness users derived from their camping experience should be an important management consideration. By understanding how people evaluate the quality of their experience managers can manage the resource and the recreationists who use the resource. Researchers can assist managers by providing information on the characteristics of the experience that are most important for a satisfying experience and particularly on characteristics malleable by management. This paper reports on research intended to aid managers by developing a better understanding of the satisfactions of a group of campers at two New York State operated camprounds in Adirondack Park, a forest preserve of 6 million acres in northern New York.

Satisfaction with an experience is a difficult concept to define and to measure empirically. Past research has used a multiple satisfactions approach to define the many dimensions of a satisfying recreational experience (Hendee 1974; Graefe and others 1981; Pierce 1980). Measurement of satisfactions has included a variety of theoretical constructs (i.e., discrepancy theory, satisfaction as a sum of separate elements, cognitive dissonance theory) (Propst and Lime 1982) but has been difficult to standardize because as Miller (1976) notes, the consumer's standard of satisfaction is being adjusted even while measurement is taking place.

While understanding the overall level of satisfaction helps managers to decide if some type of management change is needed, they can only alter certain elements under their control. By examining user satisfaction with specific components of the experience, managers can deduce what management actions will affect specific satisfaction components. Further, manipulating those components that are most important could presumably lead to more dramatic increases in overall satisfaction. Recreationists have often been asked to rate (on a Likert-type scale) the importance of the components of their experience. These importance measures were used in the weighting of satisfaction components; however, the weighting has not increased the predictive ability of the satisfaction measures (Dorfman 1979). By reviewing earlier job satisfaction research, Wanous and Lawler (1972) did find a correlation between mean importance of each component of job satisfaction and the correlation of each satisfaction component with overall satisfaction. Therefore, by using an importance scale and correlations within a satisfaction scale, the most critical components of an experience could be determined. We hypothesized that these components could be combined through factor analysis and termed critical factors because they could be used to predict camping satisfaction to the same degree that all factors predict camping satisfaction.

METHODS

The study was conducted within the Adirondack Park, a state forest preserve of 6 million acres (2 million acres are publically owned) in northern New York state required by the New York State Constitution to be maintained "forever wild." Eight hundred campers from two campgrounds, managed by the New York State Department of Environmental Conservation, were systematically sampled and sent mail questionnaires in November 1984. The referent experience was their camping trip the previous August. There is often concern about the effect of time delay between the end of the experience and the time of the questionnaire response on satisfaction, Miller (1976) hypothesizing that reported satisfaction increases with time. However, in a recent study, no such difference was found between questionnaires sent out immediately after the trip and those distributed five months later (Schomaker and Knopf 1982).

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Sources or components of camping satisfaction were identified through a review of the literature, in particular (Dorfman 1979), and by personal interviews conducted with 40 campers at Fish Creek and Rollins Pond campgrounds in July and August 1984.

The mail questionnaire respondents were asked to rate on a 7-point Likert-type scale the importance of, and their satisfaction with, 22 components of their camping experience. Other variables on the questionnaire included length of trip, number in party, activities participated in, and socio-demographic characteristics. Chi-square and t-tests were used to make comparisons between the two campgrounds. Factor analysis (principal axis factoring with varimax rotation) and multiple regression analysis were used to identify critical factors (SPSS Inc. 1983).

RESULTS

Response rates to the mail questionnaire for both campgrounds were very high: 89% (n=382) and 90% (n=293) for Fish Creek and Rollins Pond campgrounds, respectively. Statistically significant differences ($P<.05$) were found between respondents from the two campgrounds for most variables examined (table 1). In general, participation levels at Fish Creek were higher for activities requiring more mechanized equipment and multiple participants (e.g., power boating 42% vs. 9%). Socio-demographic variables also showed campers at Rollins Pond to be more likely to come from urban areas, to be younger, and to have a greater number of years of education.

Table 1.--Some participation and socio-demographic variables showing significant differences ($P\leq.05$) between two campgrounds (1984)

Variables	Fish Creek Campground	Rollins Pond Campground
	Percent	
	Activity Participation	
Fishing	61.8	49.5
Bicycling	52.1	28.0
Power Boating	41.9	8.9
Observing Wildlife	48.4	57.7
Hiking	36.1	46.8
	Current Residence	
Rural-Farm	3.4	2.1
Rural-Nonfarm	24.7	21.9
Village <5,000	17.6	11.6
Small City 5,000-24,99	28.4	25.7
City 25,000-99,999	12.6	19.9
City ≥ 100,000	13.2	18.8
	Mean	
Age of Respondent	42.7	37.9
Years of Education	13.9	15.1

No statistical differences were demonstrable between campers at the two campgrounds for the most popular activities--those in which more than 80% of the respondents participated. These activities were relaxing, sitting around the campfire, and swimming.

Because of these significant differences between campers at each campground, factor analysis of the satisfaction items was done seperately for each. Table 2 shows the five factors--solitude/rejuvenation, nature, achievement/challenge, social, and facility characteristics--and the factor loading by campground. Most factor loadings were above .40. Additionally, 51 percent and 48 percent of the variance was explained for each of the campgrounds, Fish Creek and Rollins Pond, respectively. These factors are similar to those found by Dorfman in 1979 and Graefe and others in 1981.

Table 2.--Factor loadings for five factors of a satisfaction scale for two campgrounds (1984)

FACTORS Item	Fish Creek Campground	Rollins Pond Campground
	Factor Loadings	
SOLITUDE/REJUVENATION		
Feeling of Relaxation	.82	.73
Feeling of Peace and Quiet	.82	.80
Escape Everyday Problems	.66	.77
Not Feeling Crowded	.56	.57
NATURE		
Plants	.75	.65
Wildlife	.73	.65
Wilderness	.63	.58
Enjoying the natural world	.55	.64
Scenic Beauty	.43	.60
ACHIEVEMENT/CHALLENGE		
Challenge within The Natural Environment	.81	.69
Learn New Skills	.77	.75
Physical Exercise	.48	.59
Seeing Tourist Attractions	.38	.47
Good Weather		.31
SOCIAL		
Feeling of Comaraderie	.75	.65
Strengthen Close Relationship	.70	.55
Experiences To Share	.47	.50
Meet New People	.43	.51
FACILITY CHARACTERISTICS		
Clean Areas, Facilities in Good Repair	.72	.84
Many Facilities and Services	.57	.42
No Litter	.53	.45
No Bugs	.42	.26
Good Weather	.33	

verall satisfaction as measured on a 7-point cale was high for both campgrounds (mean=6.05). omparing overall satisfaction with the sum of atisfaction components (using the summated model iscussed by Propst and Lime 1982) yielded a orrelation of .63 for Fish Creek and .52 for ollins Pond. The predictive ability of the ummated model was determined by using multiple egression analysis. The multiple R for Fish Creek as .72 and for Rollins pond was .65.

y using the correlation of overall satisfaction ith each factor satisfaction and the mean mportance of each factor (derived from the mportance scale) three of the five factors were dentified as critical factors (table 3). These hree critical factors--solitude/rejuvenation, ature, and facility characteristics--which were he same for both campgrounds, had the highest atisfaction correlations and importance means. ultiple regression analysis using the critical actors as independent variables and overall atisfaction as the dependent variable yielded ultiple r's of .655 for Fish Creek and .610 for ollins Pond. The predictive ability of critical actors was modestly lower than that of the ummated model.

ISCUSSION

wo campgrounds were selected for this study ecause although they were located near each ther, we hypothesized that they offered different amping experiences for their users and thus ampers would have different critical factors. At ish Creek a more social atmosphere prevails, ctivities are offered by the campground staff, nd more mechanized means of camping are used (53% se trailers). At Rollins Pond fewer activities re offered by the campground staff, and tents and ent-trailers are the most common means of camping 60% use tents). The results also show that ampers participated in somewhat different ctivities at each campground and had different ocio-economic characteristics. However, factor analysis described almost identical factors for the two campgrounds, and furthermore, the same critical factors were identified for each campground. This finding may not be so surprising if one believes that these critical factors are basic to any camping experience. Perhaps these results can be generalized to campers at similar campgrounds.

Since the multiple R's for the critical factor model and the summated model were so similar, it can be concluded that the two additional factors (achievement/challenge and social) did not contribute additional predictive ability to the critical factor model. In other words, one could get as good an indication of overall satisfaction by examining the critical factors as by examining all the factors.

The primary management implication of this research is that managers could most directly affect people's satisfaction by manipulating the three critical factors. Depending on the management philosophy and the desired level of overall satisfaction, a variety of actions could be taken by managers of a campground. For example, to increase satisfaction with solitude/ rejuvenation, more vegetative screening could be established as well as restriction of site rentals in congested areas. While managers are likely maintaining all the facility characteristics to the best of their abilities, if additional facilities were desired, an interpretive center or a campstore might be considered. The major management action that could be taken to increase satisfaction with nature would be the provision of more informational and interpretive services. One idea for use in the Adirondacks would be information on the life cycle of the blackfly and the most common repellants available. This information could be used to counteract the negative image of the blackfly. From our analysis, these types of management actions would have a greater impact on overall camper satisfaction than management efforts to increase achievement/challenge or social aspects of the camping experience.

able 3.--Comparison of factors for the two campgrounds in terms of mean importance and the correlation of overall satisfaction with factor satisfaction

	Fish Creek		Rollins Pond	
actor	Mean Importance	Correlation of Overall Satisfaction with Factor Satisfaction	Mean Importance	Correlation of Overall Satisfaction with Factor Satisfaction
olitude/Rejuvenation[1]	6.51	.5849	6.63	.5653
acility Characteristics[1]	6.13	.4793	5.89	.4473
ature[1]	5.43	.4780	5.70	.4563
ocial	4.88	.3953	4.55	.2336
chievement/Challenge	4.40	.3406	4.65	.3390

Chosen as a critical factor.

REFERENCES

Dorfman, P.W. Measurement and meaning of recreation satisfaction. Environment and Behavior. 11(4):483-510; 1979.

Graefe, A.R.; Ditton, R.B.; Roggenbuck, J.W.; Schreyer, R. Notes on the stability of the factor structure of leisure meanings. Leisure Sci. 4(1):51-65; 1981.

Hendee, J.C. A Multiple-Satisfaction approach to game management. Wildl. Soc. Bull. 2(3):103-113; 1974.

Miller, J.A. Studying satisfaction, modifying models, eliciting expectations, posing problems, and making meaningful measurements. In: Conceptualization and measurement of consumer satisfaction and dissatisfaction. Cambridge, MA: Marketing Science Institute; 1976: 72-91.

Peterson, G.L.; Lime, D.W. Two sources of bias in the measurement of human response to the wilderness environment. J. Leisure Res. 5:66-73; 1973.

Pierce, R.C. Dimensions of leisure. I: Satisfaction. J. Leisure Res. 12(1):5-19; 1980.

Propst, D.B.; Lime, D.W. How satisfying is satisfaction research? A look at where we are going. In: Lime, David W., tech. coord. Forest and River Recreation: Research Update; Misc. Publ. 18; St. Paul, MN; 124-133; 1982.

Schomaker, J.H.; Knopf, R.C. Effect of question context on a recreation satisfaction measure. Leisure Sci. 5(1):35-43; 1982.

SPSS Inc. SPSSX User's Guide. Chicago, IL: McGraw-Hill; 1983.

Wanous, J.P.; Lawler, E.E. Measurement and meaning of job satisfaction. J. of Applied Psychology. 56(2):95-105; 1972.

INVESTMENT THEORY: LONG-TERM BENEFITS

John R. Kelly

ABSTRACT: The history of attempts to place an economic value on nonmarket goods such as public recreation resources has been marked by measurement, method, and outcome inconsistencies. The economic premises of utility theory and a concentration on immediate perceived benefits have tended to ignore longer term benefits. Expectancy-value theory that weights possible outcomes and investment theory that incorporates developmental and social benefits are proposed for household-based study that complements on-site data and economic willingness-to-pay measures and offers a triangulation of values.

INTRODUCTION

In the past, efforts to place a dollar value on nonmarket recreation have been dominated by the requirements of federal agencies to measure the contribution to national accounts (Dwyer and others 1977). A review of the three main periods of such efforts raises a number of questions about both premises and methods (Kelly 1985). Economic premises, measurement inconsistencies, sample limitations, and strategic biases have been issues for debate. More recently, noneconomic benefits have been proposed as significant for a comprehensive valuation program.

In the first period of valuation studies, "willingness-to-pay" was measured by several methods or combinations of methods including the "unit day value" that assigns a value to each person-day of use, the survey method employing on-site questioning of users, and indices of "travel cost" to estimate value to resource users. Each approach has both theoretical and methodological problems that have led to efforts at improvement.

In the present period, research programs have both refined and extended the traditional methodologies. The relative simplicity of travel cost approaches has been complicated by formulas that incorporate alternative sites, site quality, other expenditures, and opportunity costs. Survey studies have developed scales that have strong reliability and incorporate multiple dimensions of value. Simulation models and "real-market" studies have both extended and raised questions about the validity of the more familiar methods.

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Also, in recent years a more inclusive set of possible benefits has been proposed (Kelly 1981). These so-called "social" benefits include psychological outcomes related to the environment, mental health, developmental gains, and social relationships. Societal benefit possibilities include enhancement of family interaction, social cohesion, environmental awareness, and community support.

Problems and possibilities of nonmarket valuation for recreation resources are presented more fully in "Benefits of Recreation: Past, Present, and Future" (Kelly 1985). The purpose of this presentation is to extend that argument by elaborating on the values of household-based data that employ expectancy-value rather than rational utility premises and the longer-range benefits suggested by "investment theory." The underlying assumption is that all methods and metaphors have their biases and limitations. No one is inherently so superior that it can remain unexamined or without correction.

The comprehensive aim is to develop a model that accomplishes several ends: predict recreation decisions accurately, direct resource allocation efficiently, maximize benefits in relation to resource management and development, and offer a full spectrum of recreation benefits. In order to have any chance to move toward this end, two approaches are required:

1. A continual examination of the premises, methods, and results of every approach with none held "sacred" and above such criticism.
2. A cooperative effort designed for a "triangulation" of methods and measures that incorporate the full range of recreation environments, experiences, decision factors, and outcomes. Research strategies in the end will have to be viable and reasonably efficient. However, they should not be prematurely trimmed to measurement convenience, disciplinary familiarity, or even the limitations of our personal methodological experiences.

AN ISSUE OF VALUE: LONG-TERM BENEFITS

As already suggested, each methodological model has its strengths and weaknesses. However, one limitation that seems to be endemic in all those currently employed is focus on the perceived value <u>at the time of participation</u>.

One factor in this limitation is the usual reliance on data obtained on site. Whether the method concentrates on travel costs and other direct costs or on perceived psychological outcomes, they are focused on the time-bounded experience. What did the trip to the single site or series of sites cost? The measurement is limited to the trip as the unit of study. Further, the dimensions of

value are ignored in an assumption that whatever they may be, the dollar cost represents them all.

In the "survey" approach to valuation, users are given some set of scales that may be analyzed to provide a measure of the perceived benefits to the individual recreation participant. While the scales may include items that index possible persistent outcomes as well as those within the immediate experience, the focus is on the time-bounded event. In most cases, the defined parameters are also spatial with a specific site prescribed. There is no question that validity is enhanced by such a limitation that minimizes the recall distortion when the subject is asked to look back over multiple past events. Both the usual instrumentation and the research environment tend to focus attention on perceived outcomes in that time and place. However, this research model does have the advantage of relating multiple dimensions of value to the actual locale and experience.

In research, strengths are often weaknesses as well. In the case of travel-cost and survey approaches, the focus on a defined event and resource lends both simplicity and credibility to results. However, one disadvantage is the obverse of this strength. Many recreation decisions are made and single experiences valued because they are part of a longer term frame of meaning. Life includes "lines of action" with some sequential connection. Decisions are seldom discrete and unrelated to issues of social relationships, personal development, and social and personal meanings or "identities" (Kelly 1983). What will be proposed here are complementary approaches that add to current methods by incorporating the possibility of such less-bounded dimensions.

On-Site and House-Based Data

What is the basis of the assumption that recreation benefits can be allocated to a single event, especially one that is defined as a "trip?" Is life so episodic that each discrete event--a game, a party, a conversation, a sexual action, or a meal--is separable from other actions or from the sequence of activity that precedes and follows it? Do we act toward our children as part of a program or simply in a bounded moment? Do we practice tennis or the piano unrelated to a program of skill-development? Do we plan a vacation trip solely for the satisfactions to be found between backing out of the driveway and unpacking at the end?

Recreation, like most intentioned behavior, is embedded in a multidimensional context of meaning. Seldom do we choose an activity at a particular time and place without some consideration of its meaning or its contribution to ourselves and/or others in some value-oriented scheme. We do not simply desire exercise; we seek to develop our health or physical competence. We do not only want to be with someone; we seek to express and develop a relationship. We do not enter an event with no manifest or latent concern about how we will be received and what impact that may have on the ways significant others will define and value us in the future.

The point is simply that too sharp a focus on the immediate experience of recreation distorts how we define and value the event. Our lives have continuities as well as discontinuities, connections as well as separations. Each event occurs in a context of meaning, each decision in a network of potential meaningful outcomes.

While on-site data has the value of immediacy, it also has that flaw. Further, its presumed efficiency may be suspect. Sampling issues are serious for all the reasons that any times or places will not fully represent the use of an area over a season or longer. Data tend to be limited to a single use or set of recent uses. And, most important, the spectrum or pattern of leisure engagements is either ignored or distorted by the concentration on the immediate. It may not be efficient to gather convenient data that is limited in scope.

On-site data can do more than has usually been accomplished. Both economic measures of willingness-to-pay and psychometric data identifying and measuring dimensions of the site use can be included and compared. An inclusive strategy can incorporate the usual data on travel costs, schedule of site use, and salient demographic characteristic of users with specific other direct and indirect expenditures related to the event. Indirect costs such as equipment investment and depreciation, foregone income as an opportunity cost, and estimated frequency of use can be included.

Further, value scales that have been developed for on-site use can be incorporated into the same collection procedure. Even though the measures may not mesh well with the economic, cooperative efforts can add to efficiency and enrich the analysis of benefits. The key is to design instrumentation so there is no major block to the analysis-revision-refinement process of development. From on-site data, it should be possible to produce credible analysis of multidimensional benefits related to the particular site and types of sites as well as to categories of users.

However, household-based data cannot be omitted simply because of some presumed convenience or cost-effectiveness of on-site research. To begin, the immeasurable advantage of household data is that it includes nonusers as well as users. The "willingness-to-sell" issue for valued but currently unused resources can be addressed.

At least as important is that household data is obtained at the locus of decision rather than participation. Time frames may be extended forward as well as directed backward. Particular events can be placed in the context of alternatives and other leisure commitments. The social context of decisions tends to be the immediate others of one's household with a variety of tastes and anticipations involved. The decision to allocate time and other resources to a distant locale--usually an extraordinary one--is made in a context of competing obligations and orientations. The relatively high cost is an indication of the high value placed on the event, especially when viewed in relation to alternatives requiring less preparation, organization, time arrangements, and negotiation as well as travel cost.

Taking the household as the unit of analysis also is consistent with most economic approaches to consumer decisions. Unfortunately, however, "household production function" and other models have tended to ignore the expressive and developmental elements of life together. A model that defines the household in social and psychological terms as well as economic can provide a framework for analysis with a comprehensive view of resources and aims. The allocation of resources begins in the household, not at the destination.

A number of advantages can be suggested: First, there is considerable evidence that household/ primary group factors are central to resource allocation, especially when scarce resources include time as well as money. Second, the household unit of analysis can incorporate longer term outcomes. The household receives resources, evaluates and allocates them, and in some negotiation reviews the outcomes for use in future decisions. Third, the household rather than the destination would seem to be the likely center of the cognitive or decision map. Fourth, household data can be designed for a representative sample of the entire population--current users and nonusers--in a way that picks up values associated with having available resources not salient to decisions at this time. Fifth, recreation expenditure measurement can be based on the entire household budget rather than a single trip or event. The "inputs" of resources--time, money, and personal energies--can be measured over a longer time frame than one day. Sixth, household research can include the full range of recreation investments.

In general, what is lost in immediacy is offset by inclusiveness. Eventually, comparison with on-site data could provide a base for more efficient measurement of those variables most tied to the site. This is not an argument for replacing on-site data with that obtained in the household. Rather, the two are complementary--perhaps each incomplete for valuation purposes without the other.

Any design that is built only on economic, attitudinal, or behavioral measures is threatened by the possibility of low or inconsistent correlations among dimensions (Kelly 1973). Household-based data could include all three dimensions--real expenditures, value-scale attitudes related to inputs and outcomes, and behaviors reflecting allocation decisions as well as perceived opportunities.

EXPECTANCY-VALUE THEORY AND RECREATION DECISIONS

The underlying assumption of most economic decision theory has been that people attempt to "maximize utility." They are presumed to behave rationally and logically in calculating the use benefits of any allocation of resources (Lipsey and Steiner 1975). Econometric models based on this premise have mixed success is prediction, perhaps due to other elements in the equations and despite the theoretical assumption. However, many significant kinds of economic decisions--purchase of durable goods and stock market behaviors are two--are not successfully predicted in terms of such rational models.

George Katona of the University of Michigan began as early as the 1940s to apply different premises to the analysis of economic behaviors, especially those of financial investment and consumer behavior. The group of approaches now known as "behavioral economics" has led to a number of models that either reject or enrich utility theory. Katona has demonstrated that behavioral expectations and intentions can predict economic behavior more reliably than utility models. Nobel-Prize-winning economist Herbert Simon has demonstrated that consumers construct "bounded" and simplified models of the economic world to cope with complexity. Such models are neither totally rational nor inclusive of all relevant economic variables.

Among the leading psychologists studying economic behavior are Amos Tversky of Stanford and Daniel Kahneman of the University of British Columbia. They have developed a "prospect theory" of risk-laden decisions that predicts different decision models in gain or loss situations. The point here is that the study of the cognitive processes involved in actual behaviors and decisions demonstrates the dangers of basing any research program--including nonmarket valuation--on any narrow set of econometric assumptions.

A different model would seem to be more in touch with actual decision processes. Expectancy-value theory as proposed by a number of psychologists (Feather 1982) is simple enough in its framework. It combines personal and economic expectations with the value placed on outcomes. For example, two factors may be central to a decision to go back-country camping or stay home for a party. Camping offers an opportunity for close interaction with two companions and the party for less personal exchange with twenty or so others. Camping also offers the back-country environment at the cost of a 4-hour drive; the party a lively social engagement only 15 minutes away. The decision may turn on how highly the factors are valued--benefits seen in the natural environment, relationships with the particular companions, the party format vs. aversive valuation of driving, weather uncertainties, and possible outcomes. The decision process simplifies the full universe of factors, estimates outcomes, and weighs the value placed on the selected factors in the decision "scheme."

Noneconomic factors are part of the decision to allocate resources, perhaps dominant. Further, the valuation dimension of the process is not purely rational. Emotional coloring based on past histories with certain people, environments, and experiences prevent the decision from being a systematic weighing of likely outcomes. Nevertheless, there is considerable current research identifying the various expectations that are involved in choices of recreation environments and activities. One influential line of research identified environmental, social, developmental, and health dimensions in the spectrum of outcomes related to recreation in natural environments (Brown 1981). Note that these factors or dimensions are not all limited to the immediate experience. Rather, the experience is valued for anticipated outcomes that are based in the event, but extend into ongoing social relationships and personal development.

If utility theory were both accurate and sufficient, then long-term benefits would dominate recreation decisions. If affective elements were dominant, then the immediate experience would be central. Most likely, both immediate and longer term outcomes are figured into decision schema with varying values assigned depending on such factors as just who the companions are, perceived personal needs and deficits, and a nonrational review of past experiences.

Expectations are based on past experience as well as other sources of relevant information. A kind of scenario is developed about those expectations for each episode or event in a decision scheme. Valuation is based on the salience given at that time to the range of outcomes. "What do I most need at this time?" "What do I most want in return for this investment of time, money, energy, and other resources?" And, "How do I feel about the possibilities?"

Does an expectancy-value model destroy the neatness of utility equations and render analysis either incredibly complex or impossible? Not if the approach is used as a framework for analysis that proceeds to evaluate the influence of the variables in the decision process and to "trim" and reformulate a usable analytical model. If the analytical process is grounded in behavioral realities rather than mathematical convenience, the resulting model should be no more complex than the decisions.

It would seem to be most viable to measure expectations for the immediate experience. Grounded in the time-and-place-bounded event, the expectation is relatively concrete. On the other hand, measurement of longer term outcomes is less secure because the outcomes are less clear and defined. How can personal development be more than a vague thought or the possible expression of intimacy more than a general possibility?

INVESTMENT THEORY AND VALUATION

One assumption is that decisions and valuation are intertwined. According to expectancy-value approaches, we tend to act on value-weighted expectations. Therefore, one test of any value measurement is its power of prediction. The premise of "investment theory" is that a major factor in many decisions is some evaluation of the possible return on investments of time, money, attention, and energy.

The first development of investment theory was oriented toward work and school settings (Maehr 1984). An individual's thoughts, perceptions, and beliefs are said to shape decisions in a cognitive motivational framework. However, in a parallel development, "investment" was also being proposed as a framework for understanding the developmental elements of leisure (Kelly 1983). In both cases, the underlying concept of the meaning of activity to the actor is seen as central to motivations and decisions. Maehr and Braskamp (in press) focus on two sets of cognitions--a person's sense of self and "personal incentives"--as giving form to the vague concept of "meaning."

Sense of self consists of three beliefs:

1. Self-reliance or sense of control.
2. Goal-direction or future orientation, and
3. Self-esteem or subjective judgments of ability and competence. Personal incentives refer to goals in the context of particular situations, what is anticipated from an investment. Four goal categories include activity involvement such as mastery and accomplishing a task, ego goals such as social comparison and demonstration of superiority, social goals such as acceptance and companionship, and rewards such as money and recognition. The four goals move from the most intrinsic to the most extrinsic. Both the beliefs and goals are learned in past histories. Although not fixed, they are presumed to be relatively stable as a framework for interpretation and decision.

Even though the first research on such investment schema was directed toward work and school settings, the approach can also be used in relation to family and leisure. Current research is under way in which family, community, and leisure settings and decisions are specified for the subject. Then, a scale revised from the previous research is employed to examine the extent to which factors related to "achievement-oriented" settings are also found in the more expressive settings. In preliminary analysis, we have found considerable consistency in investment orientations across the work, family, and leisure domains.

In research with a sample of 228 adults age 40 and above, separation from the work setting only slightly altered the factor structure. The four main factors for motivation or incentives were:

1. Confidence in challenge,
2. Family and familiarity,
3. Winning and recognition, and
4. Financial incentives. Clearly the first three are most related to recreation goals.

When the more achievement-directed instrument was administered to 750 adults in a variety of white-collar work settings, four types of goals or incentives were identified: task (striving for excellence), ego (competitiveness and power), social solidarity, and extrinsic rewards. Note their similarity to those in the more general study. Further, three <u>self factors</u> were also identified: self-reliance, self-esteem, and goal direction (Wigfield and Braskamp 1984).

The main issue for consideration here is the addition of self-development and social gains to those more tied to the immediate experience of an activity. Choices seem to be made on more than short-term anticipations. The larger scheme for decision and valuation includes the existential element of "becoming" as well as doing (Kelly 1986). There is a forward thrust of action in which current investment is hoped to lead to eventual gain. Such gain can be purely economic. However, more often--in work as well as in leisure--the gain is multidimensional and includes the following factors:

-A definition of the self

-A sense of "becoming" in which the self is expected to develop in the action context

-A social component in which relationships and roles are expected to yield affective and status rewards in some mix, clearly or only vaguely defined

-An immediate experience in which the longer term incentives result from the particular conditions of "doing the activity" in its environment.

Valuation, then, in its decision context is more than a simple calculation of use value. However, it is also more than anticipation of immediate experience or affective outcomes. According to investment theory, an activity may be chosen and valued because of its "fit" into the investment scheme of the actor--the realization of valued goals in relation to self-beliefs about the present and the future. One aspect of the related research agenda is to begin to be able to specify the environmental and activity contexts in which the goals are expected and valued.

THE VALUATION AGENDA

No pretense is suggested here that expectancy-value and investment approaches should replace all current and anticipated valuation research. Rather, based on the premises of complementarity and multidimensionality, this approach is offered as a useful addition to the research agenda.

One possibility is that any domination of the process by a single discipline is inappropriate and even dangerously truncated. Rather, the agenda should include economics (including behavioral varieties), psychology, and sociology along with disciplines such as geography and anthropology. A "triangulation" of methods as well as measures will serve to build confidence in results as well as avoid premature exclusion of significant elements.

A second aspect of the strategy is to incorporate both on-site and household-based data. For the reasons already introduced, each has its values and efficiencies that complement each other.

Most important is the attempt to ground economic valuation in real choices. Before enclosing valuation in a box preconstructed with materials from outside the phenomena to be investigated, research should seek to examine a full range of valuation possibilities. Research into other kinds of decisions and experiences can be useful. However, development of indices and measures grounded in recreation realities and analytical models that reflect real behaviors is necessary. Reliance on the a priori premises of any method or discipline can lead to results that are not only inconsistent but also deceptive.

REFERENCES

Brown, Perry J. Psychological benefits of outdoor recreation. In: Kelly, J. R., ed. Social benefits of outdoor recreation. Champaign, IL: Leisure Research Laboratory; 1981: 13-17.

Dwyer, John F.; Kelly, J. R.; Bowes, M. D. Improved procedures for valuation of the contribution of recreation to national economic development. Urbana-Champaign, IL: Water Resources Center; 1977.

Feather, N. Expectations and actions: expectancy-value models in psychology. Hillsdale, NJ: Erlbaum; 1982.

Kelly, John R. Three measures of leisure activity. Journal of Leisure Research. 5: 56-65; 1973.

Kelly, John R. Social benefits of outdoor recreation. Champaign, IL: Leisure Research Laboratory; 1981.

Kelly, John R. Leisure identities and interactions. London and Boston: Allen and Unwin; 1983.

Kelly, John R. Benefits of recreation: past, present, and future. In: Proceedings of the outdoor recreation trends conference II; Clemson, SC: Clemson University; 1985.

Kelly, John R. Freedom to be: a new sociology of leisure. New York: McMillan; forthcoming, 1986.

Lipsey, Richard G.; Steiner, Peter O. Economics, 4th edition. New York: Harper and Row; 1975.

Maehr, Martin L. Meaning and motivation: toward a theory of personal investment. In: Fyans, L. J., ed. Achievement motivation: recent trends in theory and research. New York: Plenum Press; 1984.

Maehr, Martin L.; Braskamp, Larry. Personal investment: motivation, achievement, and life satisfaction. Greenwich, CT: JAI Press; 1985.

Wigfield, Allan; Braskamp, Larry. Age and personal investment in work. In: Kleiber, D. A., ed. Motivation in adulthood. Greenwich, CT: JAI Press; 1985.

USE OF WILDERNESS AREAS FOR RESEARCH

Lisa Mathis Butler and Rebecca S. Roberts

ABSTRACT: To gain better understanding of actual research use of Wilderness areas, National Forest and National Park areas were evaluated in terms of extent and types of research pursued. National Park areas showed more biological research and more research overall; USFS Wildernesses showed an emphasis on recreation-related research. Large Wilderness size also was associated with more studies.

INTRODUCTION

Many federal lands, including Wilderness[1] areas, have been set aside as nature preserves. A number of reasons have been given to justify setting aside Wilderness and other natural areas from development and most "extractive" uses. One of the more notable of these reasons is the potential offered by substantially undisturbed natural areas as resources or "natural laboratories" for scientific research (Brower 1960; Farnworth and others 1981; Gilligan 1963; Hendee and others 1978; Myers 1983; Irland 1979; Krutilla and Fisher 1975; Pearsall 1984; Stankey 1982). Little is known about actual research use of these areas, however, in spite of its frequent citation as a Wilderness benefit.

The Wilderness Act of 1964 states that "wilderness areas shall be devoted to the public purposes of recreational, scenic, scientific, educational, conservation, and historical use" (PL 88-577 ¶4 §b). Whether all these uses were actually seen as important Wilderness benefits, or if some were simply included to cover all possible 'nonconsumptive' uses referred to by Wilderness advocates, is unclear. Recreation interests, combined with preservationist causes, have apparently been the driving forces behind most Wilderness designations. According to Cutler (1980),

> as a practical matter Congress establishes new wilderness primarily because of its recreational or esthetic value and because the public wants those values. The formal designations to date have had very little to do with the values to science...

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Better understanding of recent trends in the use of natural areas for scientific research may provide information important to future management and to policy efforts to maximize basic research opportunities. Further, awareness of recent research-use trends in Wilderness areas should promote attention to policy and research, and better enable formulation and evaluation of research goals by policymakers, Wilderness managers, and researchers.

Our purpose was to gain better understanding of actual research use of Wilderness areas. The objectives of the study were: to obtain an indication of the extent and types of research pursued; to determine whether differences in research occur between areas managed by different administering agencies, the U.S. Forest Service (USFS) and National Park Service (NPS); and to determine whether certain physical or geographical characteristics of Wilderness areas affect their use as research resources.

MODELS

Starting from a preliminary series of hypothesized bivariate relationships between the number of research reports (RESQ) and research topic (TOPIC), as the dependent variables, and Wilderness characteristics, as the independent variables, we investigated two sets of hypothesized relationships. Specific independent variables include managing agency (AGENCY), acreage of the Wilderness or park area (SIZE), predominant habitat in terms of moisture (ENVIRON), and proportion of the area officially designated as Wilderness (PROPW) (table 1). The hypothesized relationships may be summarized as follows:

RESQ = f(AGENCY, SIZE, PROPW, ENVIRON)
TOPIC = f(AGENCY, PROPW, ENVIRON)

The independent variable PROPW was included to help control for research differences that may exist between Wilderness and nonWilderness portions of NPS areas because data were obtainable for NPS areas as a whole only.

Legislation calls for very similar management of Forest Service Wilderness areas and Park Service natural and Wilderness areas, but overall the two agencies have different approaches to land management and different 'personalities.' We

[1] Officially designated areas are referred to as "Wilderness" (capitalized) in this paper; "wilderness" refers to a more generalized concept of wildlands.

Table 1.—Variable acronyms, definitions, and categories

Acronym	Definition	Categories
Dependent Variables		
RESQ	Number of identified research reports for each Wilderness[1]	--
TOPIC	Primary subject matter addressed by the research reported[1]	Recreation (Rec), General ecology (Eco), Earth science (ES), Botany (Bot), Zoology (Zoo), Other (O)
Independent Variables		
AGENCY	Agency administering the Wilderness	U.S. Forest Service (USFS), National Park Service (NPS)
ENVIRON	Predominant habitat type within the Wilderness[1]	Arid, mesic, wetland
SIZE	Area (acres) of the Wilderness (USFS) or park (NPS)	--
PROPW	For areas administered by the NPS, proportion of the park that is formally designated Wilderness (= 1.00 for USFS Wildernesses)	--

[1]calculated by authors

thought it highly likely that the multiple-use oriented Forest Service and the preservation oriented Park Service would exhibit different research use even on managerially similar lands. Wilderness areas also differ in environmental and other administrative characteristics, including natural resource base and size (acreage). Such differences were expected to result in differences in research use of these areas, both in topics and number of reported projects. Few large wetland areas have been given public protection, and many unprotected areas have been substantially modified. Protected wetlands therefore offer uncommon ecological research opportunities. While arid lands may also offer unique research opportunities, recent preservation and research interests seem to be more water-related, with less productive lands of somewhat less concern. A second influence on the research/environment relationship may result from a greater attraction of water bodies, relative to desert environments, for recreationists. Acreage was hypothesized to relate to research because a) larger size should mean a larger and more varied resource base (more research opportunities), and b) larger size is likely to result in greater recognition of Wilderness areas.

METHODS

The hypotheses were investigated through an analysis of reported research conducted in Wildernesses. The core of the data base for the analysis consisted of a bibliography of such research in Wilderness areas administered by the National Park Service or the U.S. Forest Service. This section describes (1) previous investigations and the methodological approach used here, (2) methods used to build the bibliography, (3) selection of study areas, and (4) statistical procedures used to evaluate the hypotheses.

Previous Investigations and Approach

Of the few studies addressing research use of natural areas, two concerned with science programs in U.S. Biosphere Reserves were recently completed (Mack and others 1983; Turner and Gregg 1983). Both these studies addressed the status of scientific activities and resources, based on the perceptions of adequacy by Biosphere Reserve staff, through questionnaire/survey techniques. Mack surveyed NPS units only; Turner and Gregg surveyed a mix of Reserves, divided into groups of "observational" and "experimental" areas.

More closely related to this study was a project conducted some time ago by an American Association for the Advancement of Science (AAAS) study committee on natural areas as research facilities. The data base used for this study was composed of a bibliography of "papers resulting from work done wholly or in part utilizing protected natural areas" containing about 2400 works of page to book length (AAAS 1963). In the opinion of the AAAS investigators, the bibliography constituted a reasonably significant sample. Data were analyzed by marking the sciences represented by each entry, as indicated by title, and summarizing findings as generalizations about research use of natural areas. This study considered all types of natural areas, and no dates were specified for the bibliographic entries collected.

A bibliography-based approach to analyzing research done in Wilderness and park areas is the most comprehensive possible at this time, and we followed in the tradition of the AAAS study in our approach to data. Research that is unreported, and so cannot help to build our body of knowledge, is excluded, while a consistent sample of that reported is included. Entries describing reported research from Wilderness areas supply information describing both research topic and number of

research reports. The topic "botany" includes research in plant pathology and plant ecology; "zoology" includes animal ecology studies. "General ecology" includes studies addressing more complex plant-animal relations that could not be clearly placed in either "botany" or "zoology". The "earth science" topic includes such areas as geology, geomorphology, and soil science, and "other" ranges from remote sensing to archeology.

Bibliography

A bibliography of research conducted wholly or partly in the Forest Service Wildernesses and Wilderness-containing NPS areas was compiled. Research reported from 1970 through 1980 was included, thereby restricting the data base to recent but accessible citations. A number of sources were consulted, including existing bibliographies, agency publications, computerized data bases, Dissertation Abstracts International, and agency personnel. Final entries included journal articles, agency publications, dissertations, books and book chapters, and in-house reports. A wide variety of journals were represented, such as Quarternary Research, Journal of Forestry, Bryologist, Herpetologica, Journal of Leisure Research, and Sedimentary Petrology. Identification of entries was made primarily from keywords, particularly the names of Wilderness areas, found in titles and abstracts. Conventions were followed in order to make determinations of whether to include or exclude particular works as consistent as possible. For example, papers of unknown dates were omitted and studies that could not be identified as taking place in, or being reliant upon information from, at least one of the areas under consideration were omitted. The bibliography was made up of 808 entries, with 851 citations to areas included in this study (research projects sometimes used more one than area).

Study Areas

The extensive nature of the National Wilderness Preservation System required selection of a sample of areas for this study. Of the 54 original USFS-administered Wilderness areas, the 53 that remain distinct were considered, as were 22 of the first 25 NPS areas to contain Wilderness. One Forest Service area was excluded because it was later combined with another Wilderness; three NPS areas were excluded on the basis of very small Wilderness size, very small Wilderness proportion, and/or very recent inclusion in the National Park System. These decisions were based on the assumptions that research conducted in longer established areas would be most easily identifiable and would afford a larger sample. Management of NPS Wilderness differs little from management of the entire NPS area (Whisenant 1984); identification of research is more likely to be made with the National Park as a whole; and wilderness values are generally recognized over larger portions of Park areas than are included within Wilderness boundaries. Consequently, research conducted in any part of a National Park area was included unless it could be identified as nonWilderness research. To control for any bias introduced by the inclusion of park areas outside Wilderness, the independent variable PROPW was included in all statistical analyses. In no case was the variable significant, lending support to the hypothesis that Wilderness and nonWilderness portions of NPS areas are perceived and managed similarly.

Statistical Procedures

The statistical procedures were designed to estimate and test models for the number of research reports per Wilderness and the distribution of research topics as functions of administration and environment. The model explaining number of research reports per Wilderness (RESQ) as a function of AGENCY, SIZE, ENVIRON, and PROPW was estimated using standard multiple regression analysis (SAS Institute 1982). The model explaining the distribution of research topics (TOPIC) as a function of AGENCY, ENVIRON, and PROPW was estimated using logistic regression, a categorical variable analogue of multiple regression for models in which the dependent variable is nominal. The particular form of logistic regression used in this analysis is appropriate for dependent variables with two or more categorical responses and for a combination of categorical and continuous independent variables; it is estimated using the Newton-Raphson maximum likelihood method (Hanushek and Jackson 1977; SAS Institute 1982).

Logistic regression models express the probability of the various categorical responses for the dependent variable as a function of the values of the independent variables. Similar to multiple regression, the procedure evaluates the significance of the overall relationship between dependent and independent variables, evaluates the contribution of individual independent variables, and estimates the effect of independent variables on the probability of particular dependent responses (Knoke and Burke 1980).

The parameters β_j are most readily interpretable as the effects on the probability of topic j relative to a basal topic category, expressed in terms of the logit, or $\ln(\pi_j/\pi_{rec})$. In this case, recreation is treated as the basal category, so that individual β_j values reflect the effects of one independent variable on the relative probability of a particular nonrecreation topic to recreation. Positive parameter estimates indicate an increase in the probability of a given topic relative to recreation; negative estimates indicate a decrease. Similarly, absolute values of the parameter estimates indicate the magnitude of a particular effect relative to other effects. Tests of overall significance of the relationship are based on comparison of expected and actual cell frequencies using the L^2 statistic, frequently called the likelihood ratio, which can be partitioned to provide tests of significance of individual independent variables. Under the large-sample assumptions

Table 2.--Regression analysis of relationships between research quantity and Wilderness characterisitics

Dependent variable: RESQ	All areas			Guadalupe removed		
Independent variable	Regression coefficients	Beta coefficients	probability	Regression coefficients	Beta coefficients	probability
AGENCY	20.39	0.429	0.008	19.50	0.488	0.001
ENVIRON	5.41	0.129	0.195	8.95	0.254	0.004
SIZE	0.00003	0.368	0.000	0.00003	0.440	0.000
PROPW	-16.05	-0.143	0.347	-8.44	-0.089	0.489
Intercept	5.05	0.000	0.801	-9.19	0.000	0.524
	F = 15.519 N = 75 R = 0.470	Probability = 0.0001		F = 27.054 N = 74 R = 0.611	Probability = 0.0001	

necessary for asymptotic conditions to hold, L^2 follows the chi-square distribution.

RESULTS

Results of the regression analysis used to investigate relationships between the number of research reports per Wilderness and the independent variables are summarized in table 2. With all areas included in the analysis, the model explains 47 percent of the total variance. Managing agency and size of the area are the most important determinants of research quantity, as indicated by their beta coefficients, and are both highly significant ($p = 0.008$ and 0.0001, respectively). The positive relationship between RESQ and SIZE indicates that larger areas receive greater research attention; the large beta coefficient confirms that the low parameter estimate is an artifact of the small measurement unit (acres). The positive parameter estimate for AGENCY indicates that the number of research reports tends to be higher for NPS than for USFS Wildernesses, after adjusting for variations in area size, environment, and proportion in Wilderness.[2] ENVIRON and PROPW are not significant.

Because Guadalupe Mountains National Park was shown by leverage diagnostics to exert an inordinate influence that masked underlying trends among the majority of areas, it is excluded from a second regression model (see Wrigley 1983). This second model explains a higher percentage of total variance, 61 percent. AGENCY and SIZE remain the most important determinants of research quantity. In contrast to the first model, ENVIRON is also significantly related to research quantity; the positive sign indicates that research use increases when moving from dry to wetland areas. PROPW is again not significant.

The analysis also showed the distribution of research topics to be significantly related to the independent variables, particularly managing agency (table 3). As indicated by the cross-tabulation of research topic against managing agency, there is a significant difference in the research use of Forest Service Wildernesses and Wilderness-containing Park Service areas. The largest proportion of research reported from USFS Wilderness areas was recreation-related (50 percent), while research in the biological sciences predominates in the NPS areas (62 percent). For the Park Service areas, only two percent of reported research was in the primary topic area of recreation. We suspect that the proportion of recreation research in USFS Wildernesses would have been greater, if it were not for a relatively large number of U.S. Geological Survey (USGS) reports on the geology of Wilderness areas that appeared during this time period.

Research topic was also compared to managing agency, environment, and Wilderness proportion by logistic regression methods to take into account potential multivariate relationships (tables 4 and 5). The results indicate that agency and

[2]It should be noted that it is very likely that a number of research projects based in NPS areas were conducted in nonWilderness areas, thus exaggerating the observed difference.

Table 3.--Crosstabulation[1] of research topic by managing agency

Research topic	USFS (53 areas)	NPS (22 areas)	Total (75 areas)
	N (%)	N (%)	N (%)
Recreation	106 (50.24)	14 (2.19)	120 (14.10)
Botany	23 (10.90)	122 (19.06)	145 (17.04)
Zoology	7 (3.32)	227 (35.47)	234 (27.50)
General ecology	8 (3.79)	48 (7.50)	56 (6.58)
Earth science	56 (26.54)	138 (21.56)	194 (22.80)
Other	11 (5.21)	91 (14.22)	102 (11.99)
Total	211 (100.0)	640 (100.0)	851 (100.0)

[1]Chi-square = 341.4; degrees of freedom = 5; probability = 0.0001

environment are both significantly related to research topic, but the proportion in Wilderness is not, as would be expected if NPS Wilderness and adjacent National Park areas are perceived and managed similarly (table 4). The individual effect estimates in table 5 also indicate the importance of administering agency to the type of research conducted in Wilderness areas. The relatively large, positive estimates of the effect of Park Service administration for all nonrecreation research topics suggests that NPS administration increases the probability of all nonrecreation research relative to recreation. Conversely, the probability of recreation topics relative to all others is increased when the managing agency is the Forest Service. The estimated effects of arid and wetland environments on the distribution of research topics are smaller and most are not significant. However, the pattern of positive values for arid areas suggests an increased likelihood for other topics (except botany) relative to recreation.

DISCUSSION

The results of the statistical analyses show dramatic patterns in research use of Wilderness and Wilderness-containing areas. Reported research in NPS areas and in Forest Service Wildernesses differ significantly. Topic emphases show wide variations between NPS and USFS areas, and research quantity in Park Service areas far outnumbered that in Forest Service areas. The Forest Service and Park Service have different overall goals, reputations, and organization, or personalities, that apparently influence research use of their lands. Fish and Bury (1981) found that "each agency has emphasized some of the Wilderness Act's objectives and deemphasized others." The Forest Service has managed primarily for recreation in its Wildernesses, but Fish and Bury thought that Wilderness designation of NPS areas has little relation to recreation use. Differences in management between the two agencies are apparently carried into the realm of research management, as well, and appear to be related to differences in the role of recreation as seen by the NPS and USFS.

Emphasis on research particularly useful for Wilderness management exists for the Forest Service (see Anderson 1984; Lucas 1972). The special nature of Wilderness areas, as opposed to the majority of multiple-use USFS areas, creates special management needs for the USFS. Unlike most Forest Service areas, Wildernesses are not established for a variety of uses--they are established primarily for the purposes of recreation and nature preservation. Recreation, as the dominant human use, is the Forest Service's major Wilderness management concern, and we postulated that emphasis in USFS Wilderness would be on recreation research. For example, research use of the Rawah Wilderness, which is used by both university and agency personnel, has been focused primarily on recreation (Fager 1984). Recreation researchers are also likely to see Wilderness designation as important to recreation characteristics and recreationist-nature interactions, so that researcher perceptions, beyond those of the managing agency, may also play a part in skewing topic orientation toward recreation in the Forest Service Wilderness areas. Designation is not necessarily seen as important by other types of researchers. The secondary importance of earth science research is apparently related to a number of USGS reports on the geology and geological resources of Wilderness areas that were done in the 1970s. The Wilderness Act provided for USGS and Bureau of Mines surveys of the mineral values of Wildernesses, and provided for the withdrawal of minerals from new claims as of 1 January 1984 (PL 88-577 ¶4§d).

In NPS areas, recreation-oriented research is rare and natural science is much more common. The Park Service has a preservation and 'nonconsumptive' use purpose throughout its land system, in contrast to the Forest Service. Wilderness areas and Wilderness-containing areas in the National Park system are more likely to be seen as similar to other areas under its administration. Management needs would therefore be less specialized and more generalized research would seem appropriate to Park Service administrators. National Park areas are probably also more widely recognized as resources by researchers in a range of disciplines. This, too, would lead to a different pattern of research topics than in Forest Service areas.

Wilderness management concerns of the Forest Service, besides affecting dominant research topics, apparently also affect research quantity. A desire to minimize even research impacts on its Wilderness areas is implied by Forest Service policy that encourages research outside Wilderness when similar areas are available (Kehrberg 1984; Peterson-Cullus 1984). NPS areas receive more research use, probably due to differing NPS and USFS perceptions of Wilderness management needs and differing researcher recognition of the suitability of areas as research sites.

Research use of wilderness areas is affected by the areas' environmental characteristics, as well as by administration. The multiple regression results indicate a tendency for wetland areas to receive more research use than arid areas. Although environments are generally not significant as determinants of research topic, the

Table 4.--Logistic regression analysis of the relationship between research topic and wilderness characteristics: Chi-square analysis

Dependent variable: TOPIC (N=851)

Independent variable	Degrees of freedom	Chi-square	Probability
AGENCY	5	73.23	0.000
ENVIRON	10	41.94	0.000
PROPW	5	6.42	0.267
Intercept	5	10.67	0.058
L	95	271.25	0.000

Table 5.—Logistic regression analysis: Estimated effects on the probability of nonrecreation topics relative to recreation topics [$Ln(\pi_j/\pi_{rec})$]

	Independent Variable				
	β_{0j}	β_{1j}	β_{2j}	β_{3j}	β_{4j}
Topic (j) β_j:	intercept	AGENCY =NPS	ENVIRON =arid	ENVIRON =wetland	PROPW
Botany	−0.130	1.961**	−0.008	−0.113	0.524
Zoology	−0.194	2.744**	0.170	0.160	0.324
Gen'l ecology	−0.070	1.697**	0.035	0.408	−0.781
Earth science	0.875	1.354**	0.452	−0.511*	−0.075
Other	−1.077	2.011**	0.709*	−0.140	1.125

** Significant at 0.01 significance level * Significant at 0.05 level

results do tend to support some hypothesized relationships. Higher likelihood of zoology and general ecology topics in wetlands (table 4) give some support to our reasoning that the large protected wetlands of the Wilderness System offer uncommon biological research opportunities. It was not surprising that arid environments seem to be associated with decreased recreation research, relative to most other topics (table 4), since recreationists are generally thought to be attracted to water. Also, the dryland NPS and USFS areas in this study often contain special life forms and resources for paleontological, geological, and archaeological study which may strengthen the likelihood of such topics relative to recreation topics.

Park Service areas are not likely to exhibit great differences in research use with differences in Wilderness proportion, as was indicated by results of the analyses. This is not surprising, as NPS areas with designated Wilderness exhibit wildland characteristics over large areas, though statutory Wilderness area varies. In NPS areas, the protected nature aspect is more important to researchers than Wilderness designation, since management of Wilderness and nonWilderness portions of an NPS area is very similar, and recognition of these lands as research resources is made with entire parks or monuments rather than with a particular Wilderness within a park. On the other hand, Forest Service Wildernesses are more readily distinguished as natural areas managed differently than surrounding National Forests. USFS Wildernesses may also overlap National Forests, and so are more likely than NPS areas to be distinguished by their specific Wilderness names (such as the Selway-Bitterroot Wilderness or the Hoover Wilderness). Both NPS and USFS areas should have greater recognition, and a larger number of research opportunities, as size increases. There is a tendency for larger areas to serve as laboratories for a greater number of studies, probably because they are better-known than small areas, especially in the case of Forest Service Wildernesses, and because a larger number of research opportunities exist in larger areas.

CONCLUSIONS

Many reasons for setting aside natural lands have been suggested. Continued protection of natural areas in the future is likely to become more and more dependent on 'practical' or easily perceived and communicated uses of these areas. This study represents an attempt to analyze the oft-mentioned, but little-studied, use of Wilderness areas for research.

This study addresses possible research differences on lands under designations where basic management would theoretically be quite similar. Although legislation might lead to an expectation of similar use patterns, administration by different agencies can lead to very different research use. This becomes clear in the case of the Forest Service and Park Service, where dramatic differences in research topics and in research amounts exist between similar areas administered by the two agencies.

With better understanding of research use of Wilderness and other natural lands, policy questions regarding agencies and their administration of research on natural lands can be better addressed, particularly if research is indeed a desirable use of these lands. The results of this study lead us to suggest some questions for consideration when the role of research in Wilderness is addressed by policy and management decisions:

1. Should one agency, over another, be assigned the administration of areas with more research potential? The Park Service currently exhibits much more use of areas for research than does the Forest Service. Is Park Service administration better for areas with particular research interest?

2. Should some research topics be given precedence over others, or should agency 'specialization' in certain topics be promoted or discouraged? A specialization of research in NPS areas toward biology and in USFS areas toward recreation, whether accidental or by design, is occurring. Is this desirable?

3. Should research use of Wilderness lands be actively encouraged or discouraged, or should areas be given designations (such as Research Natural Area) in addition to, or other than, "Wilderness" where research is important? Seemingly, "Wilderness" in the USFS has so far implied protection, even from research. Would other designations lead to better recognition, and more use, of research potential in these areas?

4. Should larger Wildernesses be promoted, in order to promote research? The quantity of research is significantly related to the size of Wilderness areas. Does this mean research is better served by designation of larger areas?

Research is both dependent on and helpful to management decisions, but actual contributions of Wilderness, Wilderness management, and science to each other need to be better understood. Wilderness apparently does have much to offer scientists in a variety of disciplines, as indicated by the number and range of research reports identified in this study. Wilderness has thus benefitted both researchers, who have been provided with the natural resources they find necessary or desirable, and, we assume, the disciplines to which these researchers contribute. This study demonstrates that research use varies from Wilderness to Wilderness, with variations in administering agency, size, and environment affecting amounts of research, as well as research topics investigated. Depending on whether or not it is deemed appropriate for the Forest Service and the Park Service to approach research in Wilderness in very different ways, some revision of legislation or agency management guidelines may be in order, and clarification of research goals for Wilderness areas may be needed by each agency or for individual Wildernesses.

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REFERENCES

American Association for the Advancement of Science (AAAS), Study Committee on Natural Areas as Research Facilities. Natural areas as research facilities. American Association for the Advancement of Science; 1963: 193 p. + appendices.

Anderson, Charles G. [Letter to Lisa M. Butler.] 1984 December 20. 1 leaf.

Brower, David, ed. The meaning of wilderness to science: proceedings of the sixth biennial wilderness conference. San Francisco: Sierra Club; 1960. 129 p.

Cutler, M. Rupert. Wilderness decisions: values and challenges to science. Journal of Forestry. 78(2): 74-77; 1980.

Fager, B. L. [Letter to Lisa M. Butler.] 1984 November 7. 2 leaves.

Farnworth, Edward G.; Tidrick, Thomas H.; Jordan, Carl F.; Smathers, Webb M., Jr. The value of natural ecosystems: an economic and ecological framework. Environmental Conservation. 8(4): 275-282; 1981.

Fish, C. Ben; Bury, Richard L. Wilderness visitor management: Diversity and agency policies. Journal of Forestry. 79(9): 608-612; 1981.

Gilligan, James P. The wilderness resource. In: Leydet, Francois, ed. Tomorrow's wilderness: proceedings of the eighth biennial wilderness conference. San Francisco: Sierra Club; 1963: 49-58.

Hanushek, Eric A.; Jackson, John E. Statistical methods for social scientists. New York: Academic Press; 1977. 374 p.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Misc. Publ. No. 1365. Washington, D.C.: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Irland, Lloyd C. Wilderness economics and policy. Lexington, MA: Lexington Books; 1979. 225 p.

Kehrberg, Ernest. [Letter to Lisa Butler.] 1984 November 8. 2 leaves.

Knoke, David; Burke, Peter J. Log-linear models. Beverly Hills, CA: Sage Publications; 1980. 80 p.

Krutilla, John V.; Fisher, Anthony C. The economics of natural amenities: studies in the valuation of commodity and amenity resources. Baltimore, MD: Johns Hopkins University Press; 1975. 292 p.

Lucas, Robert C. Forest Service wilderness research--the problem, research to date, and needed research. RWU-1903, Publ. No. 12. Inservice Report. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Research Work Unit; 1972. 22 p.

Mack, Allison; Gregg, William P., Jr.; Bratton, Susan P.; White, Peter S. A survey of ecological inventory, monitoring, and research in US National Park Service Biosphere Reserves. Biological Conservation. 26: 33-45; 1983.

Myers, Norman. Conservation of rain forests for scientific research for wildlife conservation, and for recreation and tourism. In: Golley, F. B., ed. Tropical rain forest ecosystems: structure and function. Amsterdam: Elsevier Scientific Publishing Company; 1983: 325-334.

Pearsall, Samuel Haff III. In absentia benefits of nature preserves: a review. Environmental Conservation. 11(3): 3-10; 1984.

Peterson-Cullus, Traci A. [Letter to Lisa M. Butler.] 1984 January 23. 1 leaf.

SAS Institute Inc. SAS users guide: statistics, 1982 edition. Cary, NC: SAS Institute Inc.; 1982: 39-84, 269.

Stankey, George H. The role of management in wilderness and natural-area preservation. Environmental Conservation. 9(2): 149-155; 1982.

Turner, Monica Goigel; Gregg, William P., Jr. The status of scientific activities in United States Biosphere Reserves. Environmental Conservation. 10(3): 231-237; 1983.

Whisenant, Keith A. [Letter to Lisa M. Butler.] 1984 October 23. 1 leaf.

Wrigley, Neil. Quantitative methods: on data and diagnostics. Progress in Human Geography. 7(4): 567-577; 1983.

BATTLING SATAN IN THE WILDERNESS: ANTAGONISM, SPIRITUALITY, AND WILD NATURE IN THE FOUR GOSPELS

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ABSTRACT: This study considers the relationship of events in the four Gospels to wild nature, cultivated and developed sites. The Gospel writers presented wild nature as the place of spiritual encounter, both divine and satanic, and emphasized the personal or individual in relation to the wilderness. Since most adverse events occurred in buildings or in urban settings, the synagogue, the temple and praetorium appear to be the preferred habitation of evil.

INTRODUCTION

In the opening chapter of their widely used text, Wilderness Management, Hendee and others (1978) repeated a commonly held notion that the Judeo-Christian concept of "wilderness" is largely negative. They suggested:

"The word appeared in the 14th Century English translation of the Bible from the Latin and was used as a synonym for uninhabited and arid lands of the Near East . . . . Because their [the land's] inhospitality was due to the absence of precipitation, and because precipitation was beyond human understanding, such lands were perceived as evidence of God's displeasure. The wilderness was a cursed land, and when the Lord set out to punish, through act or parable, the wilderness was often the setting . . . . Wilderness was not only the setting for the [Israelites'] 40-year wanderings inflicted as punishment from the Lord for their misdeeds, but it was also a place where they could prove themselves worthy of the Lord, and subsequently the Promised Land. The wilderness, thus, was a place where one might purge and cleanse the soul in order to be fit in the sight of God. Jesus' 40 days in the wilderness, fasting and resisting the temptations of Satan, was preparation for speaking to God . . . . Wilderness then, in early Judeo-Christian thought, was the place of evil -- the antithesis of good."

This position was originally presented to the environmental community by Nash (1973), who discussed the Israelite wanderings in Sinai and concluded: "There was no fondness in the Hebraic tradition for wilderness itself."

Nash cited Mauser (1963), who outlined Christ's several confrontations with Satan or demons in the desert and by the sea, and Williams (1962), who pointed out that for "the indigenous Canaanites, the desert was peopled with dragons, demons, and monsters of the night." Williams suggests that some of this mythology was absorbed by the Hebrews. Further, the wilderness has been associated with both sin and, being untillable, the curse spawned by the Fall.

Not all theologians agree that wilderness is a place of evil, however. W. D. Davies (1974) warned against an overemphasis on the wilderness "as under curse," and pointed out it could also be "the scene of Divine Presence, of the revelation of the Name, of the Covenant, and the giving of the Law." Israel's relationship to Yahweh while in the desert appears in a positive light in the prophets Hosea and Jeremiah, and although the prophets may not have idealized the desert, during the time in the wilderness Israel was faithful and found grace (deRoche 1983).

The purpose of this paper is to investigate one section of the New Testament, the four Gospel narratives of Matthew, Mark, Luke, and John, and to analyze the attitudes expressed towards wild nature, in comparison to cultivated landscapes and urban and household settings. The questions to be answered include: Is wild nature associated with evil or the demonic? Is wild nature associated with other sorts of antagonism or strife? What sorts of things happen in natural versus urban settings? And is there any evidence for prejudice for or against wild nature in these accounts? The paper ends with a few comments on Christian spirituality and wilderness values.

METHODS

A preliminary problem is the difficulty of translating Greek into English. For example, the Greek word eremia, translated "wilderness" in the King James Bible, is probably more properly translated

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as "desert" in modern English. To avoid confusion, the term "wild nature" will be used in this paper for areas without a continuing human presence, and the Greek texts of the Gospels will be consulted to determine how specific vocabulary is used.

The four Gospels are not independent documents. Three of the Gospels, Matthew, Mark, and Luke, are termed the synoptic Gospels and stem from common sources. Mark is considered by most critics to be the oldest of the three and probably the manuscript upon which the other two are based (Barclay 1975; Martin 1975). Matthew and Luke have an additional body of common material, often called "Q," from the German word Quelle, meaning source. The author of John may or may not have had one of the other Gospels available, and presented many passages not found in the synoptics.

As Biblical critics have noted, most of the descriptions of people in the Gospels are very simple, often almost free from adjectives, and contain no unnecessary information. In the case of landscapes, the approach of the Gospel writers was similar. Usually just the noun is used, and further description is rare. The few expanded descriptions are brief by modern standards. In the feeding of the five thousand in Mark for instance, the people sat "on the green grass" (Mark 7:39), and in the transfiguration, Jesus led Peter, James, and John up "a high mountain" (Mark 9:2).

The role of landscape, then, can be largely analyzed by an investigation of nouns and a few adjectives, indicating setting. As a first exercise, I used a listing of all the Greek words in the New Testament to construct a sublist of landscapes and settings (from the New Revised Standard Concordance by Morrison 1979). I then divided these words into three categories:
(1) wild nature, including lakes and shores, rivers and springs, deserts and isolated places, mountains and hills, valleys, rocks and caves (aigialos, paralios, parathalassios, limne, thalassa, potamos, Jordan, pege, eremia, eremos, oreinos, oros, cheimarros, spelaion, petra, laxeutos);
(2) agricultural and settled districts including fields, regions, districts, and gardens and grain fields (chora, horion, perichoros, agros, kepos, Gethsemne, paradeisos, sporimos); and
(3) developed sites, including cities and towns, and buildings (kome, komepolis, polis, Jerusalem, oikos, oikia, synagoge, hieron, naos, aule, gazophylakei, or praitorion).

Using a Greek synopsis (Huck and Greeven 1981), an English synopsis (Aland 1982), and the Greek text of Aland and others (1975), I then computer-coded all the passages using the words to describe an actual setting (not including parables and prophecies). Each time one of the selected words appeared as a setting, the surrounding passages clearly referring to events at that site were inspected to determine:
(1) The presence of Christ and His followers, including Christ, John the Baptist, few disciples, most or all of the disciples, Christ's family, the multitude or crowd, and others (neutral or supportive individuals and groups);
(2) the presence of antagonists, including Satan or demons, scribes, Pharisees, priests or lawyers, representatives of the government, or "the Jews" (as a group, the term "Jews" is usually used negatively);
(3) the initiation of active ministry, including teaching or preaching, healing, the driving out of demons, commands or prophecy, miracles, the calling of disciples, baptizing or anointing, prayer, pronouncement of faith statements, and other physical ministries;
(4) the occurrence of spiritual transitions, such as baptism or calling to ministry, or of theophanies, including Satan, the dead (Moses, Elijah), angels, the Holy Spirit, and Christ (risen or walking on water);
(5) the presence of threats to life or obstruction of ministry including physical difficulties (storms, lack of food), verbal confrontation, threat of injury, injury, and death;
(6) other circumstances, including passive interaction by Christ, withdrawal or rest, traveling through an area, description of a site, and favorable circumstances (lack of adverse conditions). All these factors were presence/absence coded, relative to the setting.

In each case, only the situation immediately associated with the location was included. If there was a change in the type of activity, the characters present, or the structure of the text (such as change from a narrative about Jesus' movements to a series of prophecies), coding did not include activities or persons present after the point of change, even if it was possible the location had not changed. In other words, the coding only concerned the passages immediately associated with the noun in question. Therefore, many events in the Gospels, particularly those with no location mentioned in the pericope, were not included in this exercise. If the word describing a setting was found in a prophecy, a parable, a quotation concerning a location other than the site of immediate action, a clause describing someone's place of residence, or some other form not referring to the location of immediate action, the passage was not included.

Sorting was done through the SAS statistical analysis system (SAS 1982). All correlation coefficients are product moment. One asterisk indicates a 0.05 probability, two asterisks a 0.01 probability that the coefficient is significant. It should be remembered, however, that it is highly unlikely that this sample of texts exhibits normal error properties. All quotations are from the Revised Standard Version of May and Metzger (1973).

RESULTS

The coding produced 98 events associated with wild nature, 66 associated with cultivated sites, and 185 associated with developed sites. John used the nouns of location less frequently than the other Gospels (35 as compared to 106 for Luke), but the percentage of references to wild nature is comparable (27 percent for John, 35 percent for

Matthew, 29 percent for Mark and 22 percent for Luke). Luke had a larger percentage of references to developed locations than Matthew or Mark, and this appears to be due to Luke's greater emphasis on events in Jerusalem.

Wild nature had a much lower association with the presence of antagonists (18 percent of the cases) than did cultivated (44 percent) or developed (45 percent) settings. Satanic or demonic antagonists were more frequent in wild nature (15 percent) than in cultivated (6 percent) or developed (5 percent) settings, but accounted for only a few more encounters in wild nature (13 cases) than in developed settings (9 cases). [NOTE: All these figures represent the sums of all four Gospels.]

Physical difficulties, such as storms, also had a high association with wild nature (14 percent), as opposed to cultivated (3 percent), or developed settings (0 percent). By contrast, the scribes, Pharisees, priests, lawyers, and government antagonists appeared three times in wild nature, 22 times in cultivated sites, and 75 times in developed sites. Although the multitude frequently followed Christ and John the Baptist into the wilderness, their enemies rarely did. The primary appearance of human antagonists in wild nature was when the Pharisees and Sadducees came to be baptized by John. John rebuked them saying, "You brood of vipers! Who warned you to flee from the wrath to come?" (Matthew 3:7b).

To distinguish among the treatments in the different Gospels, and to compare incidents with several locations, all demonic and satanic encounters were investigated, including those in prophecies. In Mark, probably the earliest of the Gospels, the temptation by Satan is very briefly described (Mark 1:12-13), whereas the encounter with the unclean spirit in the synagogue, a few verses later, reports in detail the cries of the demon, Christ's reply, and the comments of the onlookers (Mark 1:1-28). Mark followed this with a description of ministry at the house of Simon and Andrew and again gave attention to the casting out of demons, and to Christ's power over them. In Matthew's account of the temptation, Satan took Jesus to the Holy City and set him "on the pinnacle of the temple" (Matthew 4:5), then took him to a "very high mountain and showed him all the kingdoms of the world . . ." (Matthew 4:8). The temptation is thus not just a desert phenomenon, but includes a building and a mountain, both sites often associated with the appearance of Yahweh himself. In ten of 14 demonic or satanic encounters described in the Gospel texts, a building such as a house or a synagogue or a village or town is mentioned in at least one of the Gospel accounts.

Another passage, mentioned by authors such as Mauser (1963) as a text supporting the association of the demonic with the wilderness, is the healing of the dumb demoniac (Luke 11:14-26). Jesus commented: "When the unclean spirit has gone out of a man, he passes through waterless places seeking rest . . . ." This implies an affinity between the unclean spirit and the desert. Christ continued, however: " . . . and finding none, he [the unclean spirit] says, 'I will return to my house from which I came.'" The Greek for house in this case is "oikos," implying a demonic preference for the comforts of the human.

Mauser (1963) suggested that Christ stilling the storm also represented a type of encounter with the demonic; thus, the physical difficulties encountered in wild nature were actually confrontations with evil. This was probably overdrawn, however. The actions of Christ in calming the tempest may be interpreted as exactly that -- a demonstration of power over the forces of nature, proving His role as the Holy One of God. This operates in tandem with His driving out of the demonic. The only source of power remaining is the evil in the human heart, which is ultimately conquered by self-giving sacrifice rather than by confrontation.

The presence of antagonists was associated with all major forms of wild nature, including lake, river, mountain, and desert, but had a greater association with deserts (3 of 19) and mountains (5 of 28). Only the lake or sea and the desert were associated with physical difficulties. Of developed sites, official buildings had a very strong association with the presence of antagonists. The praetorium and courtyards had a 100 percent association (10 cases), the sanctuary of the temple (naos) had 80 percent (5 cases), the temple (hieron) 60 percent (of 30), and the synagogue 67 percent (of 15). The two words for house or home (oikos, oikia) had a 43 percent and 54 percent association with antagonists, respectively. These are higher than for any setting in wild nature. The Holy City or Jerusalem had a 47 percent association. Ironically, the words for city or town (polis) and village (kome) had a very low association with antagonists (8 percent and 6 percent, respectively) when used to refer to communities other than Jerusalem. These words were, in fact, often associated with Christ's traveling ministry, including healing and teaching.

In contrast to antagonists, the crowd or multitude appeared in a higher percentage of wild settings (38 percent) and cultivated sites (33 percent) than in developed sites (17 percent). Christ's family and the general category of nonantagonists had a higher association with cultivated and developed sites (family, 9 percent and 8 percent; other, 27 percent and 22 percent) than with wild nature (family, 1 percent; other, 9 percent). The multitude followed Christ to the seaside and even into the lonely places (Mark 3:7; Mark 6:31). There was a negative correlation between the presence of the multitude and antagonists (-0.34**), and a positive correlation between the multitude and favorable circumstances (+0.44**). Christ's outdoor teaching was done with little interference from the scribes and Pharisees who preferred to confront him in buildings or in the holy city. Teaching was negatively correlated to the presence of antagonists (-0.19**), while healing showed almost no correlation (-0.02). Prayer was negatively correlated to the presence of antagonists (-0.13*), while prophecy and command were positively correlated (+.20**) to the presence of antagonists.

Ministry was frequently initiated in wild nature (68 percent). Teaching took place in or near all the major categories of wild nature, including the seaside (20 percent), river (38 percent), desert or isolated place (18 percent), and mountain (21 percent). Healing and prophecy were proportionately more frequent in developed sites, however. Healing was associated with 6 percent of wild, 12 percent of cultivated and 16 percent of developed sites. Prophecy and command were associated with 15 percent of the wild, 15 percent of the cultivated, and 39 percent of the developed sites. Favorable circumstances, free from antagonists and physical difficulties, were proportionately more common in wild nature (54 percent) than at cultivated (38 percent) or developed (36 percent) sites.

Both prayer and rest or withdrawal had an association with wild nature, and Mark emphasized Christ's attempts to retreat alone into isolated spots. Rest or withdrawal was associated with 18 percent of wild, 14 percent of cultivated, and 6 percent of developed sites. Prayer was associated with 5 percent of wild, 3 percent of cultivated, and 2 percent of developed sites. Christ was also more likely to go alone into wild nature (12 percent) than to developed sites (2 percent). When the Spirit drove Christ into the desert, Christ went alone. Mark 1:35 states that after ministry to Capernaum, "And in the morning, a great while before day, he rose and went out to a lonely place and there he prayed." "Lonely place" is "eremos topos" and might also be translated as "desert place." Mark 6:30-31 reports that after the beheading of John the Baptist: "The apostles returned to Jesus, and told him all that they had done and taught. And He said to them, 'Come away by yourselves to a lonely place [eremos topos], and rest awhile.'" Prayer took place primarily in the desert or isolated places (18 percent) and secondarily on the mountain (7 percent). Rest or withdrawal is also strongly associated with the desert or isolated places (29 percent), and to a lesser extent with other wild landscapes such as the sea (15 percent).

A very important and oft-neglected association with wild nature was that of theophanies or visionary experiences, including Satan, the Holy Spirit, Moses and Elijah, angels, and the postresurrection appearances of Christ. These visionary and auditory experiences are more common in wild nature (15 percent) than in cultivated (4 percent) or developed sites (6 percent). Not only did Satan tempt Christ in the desert, but angels came to minister to him (Matthew 4:11, Mark 1:13) at the same site. Moses and Elijah appeared on the mountain where there was also a voice from a cloud (Mark 9). A number of the postresurrection appearances of Christ were outdoors, not only in the garden, but also by the sea and on a mountain.

Luke, as discussed in Conzelmann (1961), treated the city of Jerusalem differently from the other Gospel writers. Luke mentioned Jerusalem more often and added temple scenes in the infancy narratives. This included the appearance of the angel when Zechariah entered to burn incense (Luke 1). Luke emphasizes postresurrection appearances in relation to the holy city (Luke 24) and reported that the disciples, after seeing the risen Christ, "returned to Jerusalem with great joy, and were continually in the temple blessing God." (Luke 24:52-53). Luke not only used more developed settings, but his Gospel ended on a more positive note concerning the temple. John, in contrast, ended with the appearance of Christ by the sea (John 21) and Matthew ended with Jesus meeting the disciples on a mountain in Galilee (Matthew 28:16-17).

Luke's emphasis on Jerusalem did not restrict his use of settings from wild nature and he retains most of the wild landscapes of Mark. Luke's discussion of Jerusalem could, therefore, be viewed as an addition to the imagery of place shared with Matthew and Mark, rather than a displacement of it. In Luke there was a 33 percent association of antagonists with Jerusalem, as opposed to 55 percent for Mark and 56 percent for John. Thus, Luke substantially modified the way the Holy City is associated with adversity.

A parallel to the importance of theophanies was the predominance of spiritual transitions in wild nature. These included baptism, initiation of new ministries, and the calling of disciples. Wild nature had a 26 percent association, cultivated sites 6 percent, and developed sites a 10 percent association. Examples from wild nature included the baptismal activities of John at the Jordan, Christ's temptation in the wilderness, and the calling of Simon and Andrew by the sea (Mark 1:1-16). Spiritual transitions are positively associated with Christ being alone (+0.20**) or with few disciples (+0.13*), with prayer (+0.23**) and theophanies (+0.56**). Spiritual transitions occur in all major types of wild nature, but were most frequent at the River Jordan (baptism) and on mountains.

DISCUSSION

Although demons and Satan appeared in wild nature in the Gospels, this association is hardly exclusive. Confrontations with evil spirits also occurred in houses and synagogues. Since theophanies were common in wild nature, it is more appropriate to conclude that the Gospel writers portrayed wild nature as the place of spiritual encounter, both divine and satanic. I also conclude that the Gospel writers found the synagogue, temple and praetorium to be the preferred habitation of evil.

The themes of prayer, rest or withdrawal, visionary experience, and temptation all emphasize the personal or individual in relation to the wilderness. Christ attempted to go to the desert alone to pray. If there was an absolute relation of the desert or wilderness to the demonic, it would be an unlikely site for rest and extended prayer. The idea of God appearing on a mountain is widespread in Middle Eastern religions (Clifford 1972) and the appearance of theopanies in wild nature parallels Old Testament themes such as Yahweh coming in the cloud to Mount Sinai. Such appearances may also have been related to the lack of human antagonists in wild sites. Seeking God on a personal basis was associated with isolation. The

Gospel writers clearly portrayed wild nature as an appropriate site for divine revelation.

Hendee and others (1978) give the impression that Christ left the wilderness and did not return after the temptation. In Mark, Christ not only purposefully returned to the wilderness for prayer, but the feedings of the 5,000 and 4,000 (Mark 6:30-44 and Mark 8:1-10) took place in a lonely or desert place (eremos topos) and a desert (eremia), respectively. The postresurrection appearances of Christ included meetings with the faithful, not only in the garden and in closed rooms (as in doubting Thomas), but also on a mountain and by the sea.

Hendee and others (1978) also mentioned that the "wilderness" of scripture was "inhospitable" and "uninhabited." Nash (1973) suggested that the Hebrews distinguished "wilderness" from the "'good' land which supported crops and herds." From reading the Gospels, I note first that "wilderness" produced "green grass" (Mark 6:39). In the parable of the ninety and nine sheep, Luke 15:4 indicated that the shepard left his flock in the "wilderness" or desert (where they were presumably grazing) and went after the one that was lost. Matthew 18:12 changed the location and the 99 were left "on the mountains." The fact that mountain (oros) may be exchanged for desert (eremos) indicates that the Gospel writers did not see these sites as being dissimilar. Funk (1959) suggests that the eremia of the New Testament referred to a specific area in Palestine and was not "a generic term denoting uninhabited land as such in contrast to inhabited areas."

Most of the theological discussion of setting in the New Testament has not emphasized natural versus human sites, but has discussed the importance of specific regions or locations, such as Galilee as opposed to Judea. Lohmeyer (1936) was among the first to suggest that settings in the Gospels were not mere historic records of place, but had theological significance. In Matthew and Mark, Galilee is the site of revelation and redemption, while Jerusalem is the site of rejection. This theory has been more recently supported by Marxsen (1969) who suggested: "Viewed from Mark, Jesus' decisive activity occurs in Galilee, since Galilee is the land of the imminent Parousia and thus belongs to the expectation of faith." Conzelmann (1961) suggested that Luke combined Galilee and Judea into one "holy land," and that Luke centered the events of the passion and resurrection in Jerusalem. For these authors, the geography of the Gospels was largely symbolic, and in the case of events such as the resurrection, had little to do with historic fact. Conzelmann (1961) suggested that different types of topography have different theological roles. The plain, for instance, was the place of teaching, the mountain was the place of revelation and reaches up to heaven, while the lake was associated with death and the demonic and reaches down to the abyss. The results of the present study indicated that certain types of events do tend to occur in certain types of places, but Conzelmann's (1961) arguments seem overdrawn because there is some diversity in what happens at specific types of sites (for example, teaching and resurrection appearances by the sea contrasted to the stress of storms).

Most of the adverse events in the Gospels, including verbal confrontations and bodily injury, occurred in buildings or urban settings. Theissen (1977) suggested that the Jesus movement originally was centered in the country, and "there was an ambivalent relationship to Jerusalem." Theissen noted that John the Baptist, the Essenes, and the resistance movements had their bases in the wilderness or the hill country away from the Hellenistic cities. The major renewal movements, with the exception of Pharisaism, were all rooted in the country and "dominated by trends hostile to Jerusalem." Many of Jerusalem's inhabitants were in some way dependent on the temple and favored the status quo. The temple was the foundation of the existing "social and religious system."

The Gospels, in contrast to the Pauline writings, may have an antiurban element. The matter is more complex, however, than simple negative feelings towards cities and towns. The word "polis" itself is not strongly associated with adversity in the Gospels, but there are frequent appearances of antagonists in the cultivated countryside. Since the synagogue, temple, and official buildings have a strong association with antagonists, the landscape issue is tangled in attitudes toward the religious establishment, the government, and the ruling classes. Further, Luke, a Gentile, presented the temple in a more positive light than the other Gospel writers. Resolving the question of the theological intent of the Gospels relative to Jerusalem is beyond the scope of this paper. The reader is referred to Davies (1974), Theissen (1977), and Meeks (1983) for discussions of the Jewish concept of the land and of the influence of urban culture.

Christian writings have often compared the roles of the "garden" and the "wilderness," usually finding the garden to be superior or positively contrasted to wilderness. In the case of earthly spiritual encounter in the Gospels, this is not clearly the case. Gardens (kepos) or paradise (paradeisos) are rarely mentioned in the Gospel accounts. Christ prayed at the garden of Gethesemane before the crucifixion, but was also arrested there. Matthew and Mark did not report Gethsemane as a garden (although this study classifies it as such). Luke reported the incident as occurring on the Mount of Olives (a combination of mountain and agricultural imagery). Only John specifically said that the place of arrest was a garden.

The Greek word for paradise appears only once in the Gospels. In Luke 23:43, the dying Christ said to the thief on the cross: "Truly, I say to you, today you will be with Me in paradise." The same inconsistency surrounded the burial and resurrection in the "garden." Luke 24:53, Matthew 27:60, and Mark 16:46 described only the "rock hewn" tomb. It was again John (18:41) who noted that the tomb was in a garden, and reported Mary mistaking the risen Christ for a gardener (John 20:15). The "garden," therefore, did not seem to play a consistent role among the Gospels; the fact that the tomb was in a garden is not important enough for the synoptics to mention it. The role

of the garden in the Gospels seems to be a combination of the wild and the human. Christ withdrew to the garden to pray and to deal with internal conflict. The garden was a place of spiritual transitions and of theophanies, such as the resurrection. On the other hand, Christ's enemies entered the garden to arrest Him, Peter cut off a man's ear, and Judas betrayed his master with a kiss.

It is possible that a modern Christian, in reading many of these incidents in the Gospels, does not relate to the settings of the events in personal spiritual terms. As the church became increasingly institutionalized, spiritual transition became ritualized and was brought indoors. Baptism moved from the river to the marble font, the calling of disciples shifted from the seaside to formal ordination services, and prayer moved from the isolated place to the packed church pew. A majority of ministries are now indoors, and many denominations emphasize encounters with God in organized community worship. Although there is nothing wrong with corporate or indoor activities, the value of solitude and the importance of seeking God on an individual basis or in the company of nonhuman creation is often forgotten. The Scriptures, in reporting the actions of Christ in the wilderness and on the mountain, provide a strong mandate for individual spiritual exercise in natural settings.

In summary, when all possible settings are included in a study of the Gospels, there was no evidence that the wilderness or wild nature was seen as unfavorable spiritual environment. Wild nature was, in fact, a preferred site for teaching and prayer and was also the most frequent location for direct encounter with the divine. Close examination of the texts did not support the conclusions of Nash (1973) and Hendee and others (1978) that the wilderness (or desert) or wild nature is a place of evil. Biblical descriptions of wild nature as a setting for spiritual events are varied, and have been influenced by a number of sociological and historical factors, as well as cultural and religious traditions.

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REFERENCES

Aland, K. Synopsis of the four Gospels. New York: United Bible Societies; 1982. 361 p.

Aland, K.; Black, M.; Martini, C. M.; Metzger, B. M.; Wikgen, A. The Greek New Testament. United Bible Societies; 1975. 918 p.

Barclay, W. Introduction to the first three Gospels. Philadelphia, PA: Westminster Press; 1975. 303 p.

Clifford, R. J. The cosmic mountain in Canaan and the Old Testament. Cambridge, MA: Harvard University Press; 1972. 221 p.

Conzelmann, H. The theology of St. Luke. Philadelphia, PA: Westminster Press; 1961. 255 p.

Davies, W. D. The Gospel and the land: early Christianity and Jewish territorial doctrine. Berkeley, CA: University of California Press; 1974. 521 p.

DeRoche, M. Jeremiah 2:2-3 and Israel's love for God during the wilderness wanderings. Catholic Bibl. Quart. 45: 364-378; 1983.

Funk, R. W. The wilderness. J. Bibl. Lit. 78: 205-214; 1959.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. The need for wilderness management: philosophical direction. Wilderness management. Misc. Pub. No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978: 1-24.

Huck, A.; Greeven, H. Synopsis of the first three Gospels. Tubingen, Germany: J. C. B. Mohr; 1981. 298 p.

Lohmeyer, E. Galilaa und Jerusalem. Gottingen, Germany: Dandenkoerk & Ruprecht; 1936. 104 p.

Martin, R. P. New Testament foundations: a guide for Christian students. Vol I. Grand Rapids, MI: Wm. B. Eerdmans Publ. Co.; 1975. 325 p.

Marxsen, W. Mark the evangelist. Nashville, TN: Abingdon Press; 1969. 222 p.

Mauser, U. Christ in the wilderness. Studies in Biblical theology. Naperville, IL: Alec R. Allenson; 1963. 159 p.

May, H. G.; Metzger, B. M. The new Oxford annotated Bible: revised standard version containing the Old and New Testament. New York: Oxford University Press; 1973. 1564 p.

Meeks, W. A. The first urban Christians: the social world of the apostle Paul. New Haven, CT: Yale University Press; 1983. 299 p.

Morrison, C. An analytical concordance of the revised standard version of the New Testament. Philadelphia, PA: Westminster Press; 1979. 770 p.

Nash, R. Wilderness and the American mind. New Haven, CT: Yale University Press; 1973. 300 p.

Statistical Analysis Systems. SAS User's Guide: Statistics 1982. Cary, NC: SAS Institute. 584

Theissen, G. The sociology of early Palestinian Christianity. Philadelphia, PA: Fortress Press; 1977. 131 p.

Williams, G. H. Wilderness and paradise in Christian thought. New York: Harper & Brothers; 1962. 245 p.

OPTION VALUE IN RELATION TO DISTANCE EFFECTS AND SELECTED USER CHARACTERISTICS FOR THE WASHAKIE WILDERNESS, NORTHWEST WYOMING

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ABSTRACT: Consumer surplus and option value are estimated for the Washakie Wilderness using the contingent valuation technique. Option value is found to be an important economic value for on-site visitors and off-site users residing in four cities located at different distances from the Washakie. Off-site users account for a large proportion of wilderness preservation value.

INTRODUCTION

More than two decades have past since Burton Weisbrod defined option value as a price an individual would be willing to pay to consume a commodity in the future. Weisbrod's (1964) seminal discussion of option value illustrated its potentially important role in the economic valuation of a wide range of natural environments, including wilderness. For the next 14 years while the theory was debated and refined, wilderness policy analysts were left with little idea of the magnitude of option value relative to traditional nonmarket economic values like consumer surplus. Fortunately, recent economic studies utilizing indirect measurement techniques have begun to bridge the information gap and provide quantitative option value estimates. These studies include those by Greenley and others (1981) on water-based recreation, Brookshire and others (1983) on bighorn sheep and grizzly bear, and Walsh and others (1984) on Colorado wilderness supply augmentation.

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The purpose of this paper is to present the results of research that estimated the magnitude of wilderness option value for a specific unit of the National Wilderness Preservation System (NWPS): the Washakie Wilderness. The Washakie is located in northwestern Wyoming on the border of Yellowstone National Park (see fig. 1). Selected characteristics of the on-site and off-site wilderness user groups sampled in the research are also discussed. The research confirms Cicchetti and Freeman's (1971) suggestion that omission of the option value benefit and consideration of only the consumer surplus of the expected number of users may result in an important understatement of benefits.

OPTION VALUE

Weisbrod (1964) established that option value arises under two conditions: (1) the demand for the commodity (or service) in question is either infrequent or uncertain, and (2) the commodity might be curtailed, and recommencement of the service would be difficult or impossible (in time and resources) when future demand exists. Under these two conditions individuals might be economically interested in an option guaranteeing the continued existence of some commodity, in this case of wilderness. Cicchetti and Freeman (1971) further defined option value as a risk aversion premium. That is, option value represents a premium individuals might be willing to pay to avert the risk that a valued good or service would be reduced or eliminated. Both Weisbrod (1964) and Cicchetti and Freeman (1971) recognized that option value could exist for any resource where demand or supply was uncertain, but it was not until 1982 that the effect of supply uncertainty was examined in detail. Bishop (1982) extended option value theory by showing that where only supply is uncertain, option value will be greater than or equal to expected consumer surplus for all but risk takers.

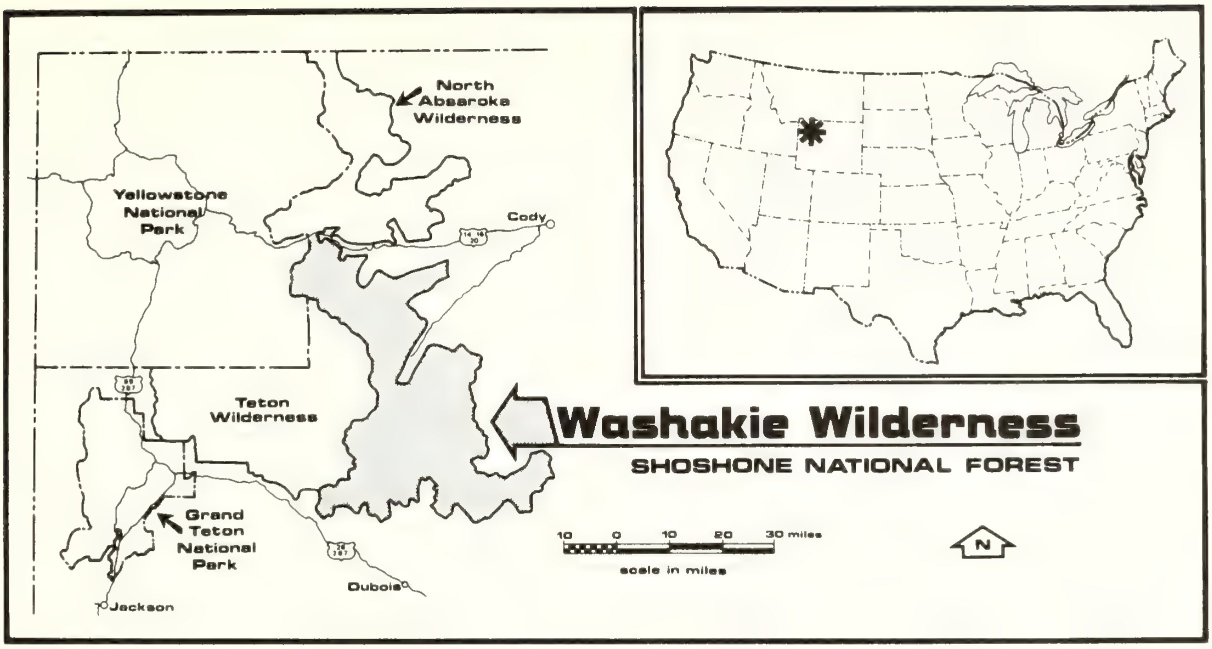

Figure 1.--Location of the Washakie Wilderness.

Given Weisbrod's definition, it is not difficult to imagine how option value might be an important part of the total economic value of wilderness when there is a risk that some, or all, of the landscape might be modified by a policy of extractive resource use. To an individual with a preference for wilderness preservation, an alternative developmental use interjects uncertainty into the future supply of valued wilderness attributes (whatever they may be). In addition, the anticipated loss of attributes might be considered an irreversible commitment (in any framework relevant to individual preferences). In any event, the satisfaction of the public's wilderness option value is a costless byproduct of preservation. But when there is a reallocation decision being considered, option value is a relevant part of any economic analysis and must be considered in the set of benefits attached to preservation or as a cost of development.

ESTIMATING OPTION VALUE FOR THE WASHAKIE WILDERNESS

In the summer of 1982 the future availability of wilderness attributes was uncertain in the Washakie Wilderness and the continued existence of unaltered ecosystems within a unit of the National Wilderness Preservation System was in question. As many as 135 oil and gas lease applications involving 480,000 acres or 70 percent of the land area of the Washakie were pending with the federal government. The U.S. Department of Agriculture, Forest Service had issued a draft environmental impact statement evaluating the merits of granting leases for the development of petroleum within the Washakie (USDA Forest Service 1981). Although the 97th Congress later eliminated the potential for oil and gas development in wilderness, the uncertainty provided by the decision-making process between 1981 and 1983 provided an opportunity to measure option value for a marginal unit of the NWPS where a realistic threat to the continued supply of wilderness attributes existed.

Option value was estimated using the contingent valuation technique. The contingent valuation technique uses direct willingness to pay questions that ask respondents to estimate values of specifically defined "goods" in hypothetical markets designed as part of survey questionnaires. The results of all indirect valuation methods applying the contingent technique are dependent on the information the survey instrument provides the research participant. A description of the economic valuation questions is provided in the appendix. A detailed description of the advantages and disadvantages of contingent valuation is well developed in the literature and will not be repeated here (Fischer 1975; Bohm 1979; Brookshire and Crocker 1981; Thayer 1981; Randall and others 1983; Rowe and Chestnut 1983). For a comparison of the technique with other valuation techniques see Schulze and others (1981), Brookshire and others (1982) and Bishop and others (1983).

To investigate the additive impact of option value, and to assess the effect of uncertainty on consumers' maximum willingness to pay for wilderness, the research was designed to provide separate estimates of consumer surplus and option value. The questions used to estimate option value were designed to provide the respondent with a vector of choices regarding the proposal to develop oil and gas in the Washakie. The vector of choices ranged from allowing oil and gas to be produced as soon as possible to allowing no development. The option values (in dollars) associated with the responses were aggregated into a dichotomy: option value associated with preference for wilderness development or for preservation (see appendix). The design enabled a more comprehensive estimation of option value, and included those individuals who are willing to pay something to avert the risk that development of oil resources would not go forward. The result is the introduction of the concept of net option value, which is defined as preservation less development option value.

RESEARCH SAMPLES

During the winter of 1982, the research questionnaire was sent by mail to individuals in four populations: on-site Washakie Wilderness visitors, on-site Yellowstone National Park visitors, and urban and rural residents from selected Standard Metropolitan Statistical Areas.

Two on-site user samples were tested. One sample was drawn from the Forest Service wilderness registration list for the southern portion of the Washakie. This list included individuals who registered before entering the Washakie over a 1-year period of record. The second on-site wilderness user sample was acquired by personally requesting participation of individuals at three frequently used trailheads. The direct on-site visitor mailing list was acquired during the month of August 1982. In addition, a small sample of Yellowstone National Park visitors was tested to provide an indication of a population lying between the extremes of actual wilderness visitors and the general population of off-site users.

In order to gain information about those individuals in the United States who might place an economic value on the Washakie as future on-site visitors, or as vicarious users, the population was sampled in four cities. The cities were chosen to represent the average age and income of the population of the United States (Szorek 1979) and also to represent populations residing at different distances from the Washakie. The selected test markets were: Salt Lake City, UT; Portland, OR; Nashville, TN; and Orlando, FL. The sampling design was also stratified to consider the rural population of areas outlying the urban samples. A composite sample of residents residing on rural roads was taken from the following locations: Riverton, UT; Estacada, OR; Mount Juliet, TN; and Oviedo, FL. The samples from the urban and rural populations were selected at random from the respective telephone directories. A total of 1,381 individuals were sent questionnaires, including 194 Washakie Wilderness users, 55 Yellowstone visitors, 200 each in the four cities, and 50 each in the selected rural places. The overall response rate was 52.4 percent, with the wilderness visitors returning 80.7 percent, the Yellowstone visitors 79.2 percent, the urban residents 44.4 percent, and the rural residents 49.0 percent.

The results obtained from the two on-site visitor samples, the four cities and the four rural samples are reported as group estimates, hereafter referred to as the wilderness visitor group, urban group and rural group.

CONSUMER SURPLUS AND OPTION VALUE ESTIMATES

Table 1 summarizes the estimates of mean annual consumer surplus, preservation option value, development option value and net option value for the Washakie based on the groups sampled. As one might expect, the magnitude of both consumer surplus and option value is larger for on-site wilderness users than for off-site users. The mean consumer surplus estimate for the members of the wilderness visitor group is more than nine times higher than for the pooled off-site user groups, while the net option value estimates are more than five times higher. However, the relative magnitude of the value estimates for the on- and off-site user groups must also be viewed in terms of the total number of individuals represented in each population. Approximately 8,000 people visit the Washakie each year and 2 million visit Yellowstone. Subtracting these individuals from the population of the U.S. leaves approximately 165 million urban and 59 million rural residents in the off-site population (US Census Bureau 1980). What the off-site users

Table 1.--Mean annual consumer surplus and option value estimates[1]

Group[2] or sample	Consumer surplus n	Consumer surplus in $	Preservation option value n	Preservation option value in $	Development option value n	Development option value in $	Net option value in $
Wilderness group	150	80.13	139	46.17	11	4.36	41.81
Urban group	305	8.97	225	9.70	76	2.78	6.92
Rural group	86	7.80	60	8.43	24	0	8.43
Wilderness visitors							
Direct contact	57	75.33	56	39.05	1	5.00	34.05
USFS registration	93	83.07	83	50.97	10	4.30	46.67
Yellowstone visitors	40	39.00	19	38.41	1	0	38.41
Salt Lake City, UT	94	9.07	56	14.46	37	3.70	10.76
Portland, OR	74	8.61	57	8.66	15	.80	7.86
Nashville, TN	75	7.69	60	5.78	14	.86	4.92
Orlando, FL	62	10.79	52	10.21	10	5.00	5.21

[1]1982 dollars

[2]Groups established after testing equality of population mean option value using the t-test or analysis of variance.

Two wilderness samples: $t = -0.68$; probability = 0.499
Four cities: $F = 1.39$; probability = 0.246
Four rural areas: $F = 0.38$; probability = 0.764

lack in per capita magnitude they regain many times over in population size. If some large assumptions are made, the annual value of the Washakie as wilderness can be calculated from these estimates in order to provide an indication of the relative importance of the economic interest of the various user groups. Aggregating across the number of Washakie visitors and the population of the U.S., the annual value of the Washakie is $975 thousand for on-site users; $2.6 billion for urban residents; and $957.6 million for rural residents. Of course the aggregation assumes that the residents of the four SMSA's are representative of the entire U.S., but the analysis does illustrate the point about the importance of off-site users in total economic value determinations of wilderness.

SELECTED ATTRIBUTES OF OPTION VALUE

In addition to determining the magnitude of wilderness option value, an attempt was made to estimate the relative importance of four motives for valuing the option. The four motives included: (1) interest in a personal visit to the Washakie, (2) interest in others being able to visit the Washakie, (3) providing the Washakie for future generations, and (4) providing for the Washakie's existence as wilderness regardless of anyone visiting it. The average percentage of option value attributed to each of the four selected motives is summarized in table 2. As one might expect, the value attributed to the desire for a personal visit is higher for those who actually have

Table 2.--Relative importance of four attributes of option value (in percent)

Group or sample	n	Percent responding	Personal visit	Others visiting	Future generations	Existence
Wilderness group	130	86.6	24.9	16.1	31.6	25.9
Yellowstone	32	80.0	11.1	25.2	33.6	27.6
Urban group	225	73.7	11.8	23.7	40.8	23.7
Rural group	59	68.6	12.2	25.7	38.2	23.7

visited the Washakie (25 percent) than for those who have not (10 percent). The largest weight consistently occurs for maintaining the Washakie as wilderness for future generations (bequest value). Future generations account for at least 30 percent in all groups, and as high as 40 percent in the urban group. Existence value accounted for approximately 25 percent of option value in all groups.

ON-SITE VISITING EXPECTATIONS

A set of questions was included in the survey to provide insight into the potential demand by the various user classes for future on-site visits. Table 3 indicates the percentage of those participants that indicated they would like to visit the Washakie, the percentage wanting to visit who think they will, and an evaluation of when they expect the visit to take place.

Two aspects of the data are noteworthy. First, as one might expect, a large proportion (89 percent) of the on-site wilderness visitor group expects to visit the Washakie within the next 5 years with 58 percent expecting to visit within 1 year. On the other hand, less than 2 percent of the off-site population expects to visit within one year and almost 50 percent indicated only that they would visit "sometime." Second, although less certain about timing, approximately 70 percent of the off-site population would like to visit the Washakie and at least 80 percent of these individuals think that they will visit. Of course, a small subset of these people will actually visit in their lifetimes. Only 3 percent of the off-site population indicated that they have visited the Washakie in the past. At the very least, the indicated willingness and desire of such a large percentage of off-site users to visit the Washakie suggests that many individuals in the United States are not averse to a personal wilderness experience. Even if interested people never visit the site, they will be willing to pay something for the option to consume it in the future (Weisbrod 1964).

DISTANCE EFFECTS

To the extent that individuals desire an on-site visit, one would expect the willingness to pay for an option to decline as distance from the Washakie increases because of the added cost of travel. Table 4 provides a summary of the net option value and distances for the on-site and off-site users.

Table 3.--Interest in visiting the Washakie Wilderness (in percent)

			Visiting expectation--years from present			
Group or sample	Like to visit	Will visit[1]	1	2-5	6-10	Sometime
Wilderness group						
Yes	99.3	99.3	58.8	30.4	5.4	5.4
No	0.0	0.7				
Yellowstone						
Yes	77.5	93.5	6.9	44.8	17.2	31.0
No	22.5	6.5				
Urban group						
Yes	68.2	81.3	1.8	41.4	10.1	46.7
No	29.8	18.8				
Rural group						
Yes	70.9	90.2	1.8	36.4	14.5	47.3
No	29.1	9.8				

[1]as a percent of those who would like to visit

Table 4.--Net option value by distance of residence from Washakie

Distance in miles	Net option value in $
Wilderness group	
1-300	48.13
301-600	52.77
601-1,200	37.11
1,201-1,800	40.83
1,801-2,500	14.23
Salt Lake City	
300	10.76
Portland	
600	7.86
Nashville	
1,300	4.92
Orlando	
1,900	5.21

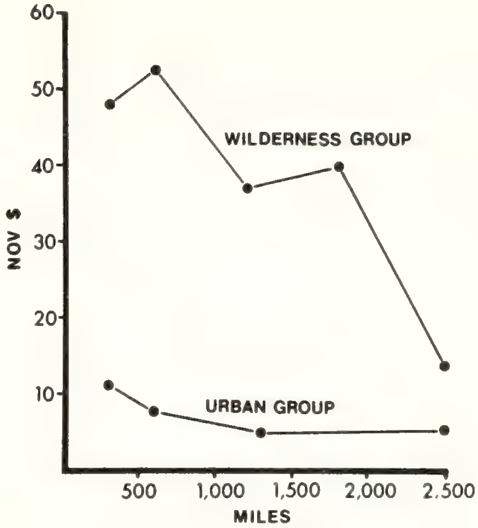

Figure 2.--Net option value by distance of residence from the Washakie Wilderness.

Although the option value estimates do diminish with distance between the four cities, except for Orlando which shows a slight increase over Nashville, the trend is not statistically significant. A nonsignificant Pearson correlation coefficient (r) results when distance and option value are tested; $r = -0.028$ (probability = 0.312; n = 305). However, the result is much different for the Washakie visitor group. The visitor group is actually faced with the cost of travel. The increasing distance of the on-site visitors' primary residence from the Washakie is reflected in lower option values. The Pearson correlation coefficient is negative and is significant; $r = -0.158$ (probability = 0.028; n = 150). The relationship of option value to distance is illustrated graphically in figure 2.

INCOME EFFECTS

Table 5 shows a breakdown of option value by six measured income levels. Analysis of variance results are also provided; they indicate that the subpopulation mean option prices are not significantly different in any group. It is interesting to note that value for an option is not related to a particular income level and that option value estimates are not biased upward by high income groups.

SELECTED SOCIOECONOMIC CHARACTERISTICS OF THE ON-SITE WASHAKIE VISITORS

Table 6 indicates selected socioeconomic data for the on-site visitor samples, including age, race, education, occupation and sex. The table also provides an opportunity to compare the Forest Service registration list with a sample that includes all visitors from selected trailheads. The two samples do vary with regard to the selected socioeconomic variables, but large deviations are few. Option value estimates from the two on-site samples were determined by analysis of variance to have originated from the same population. More research is needed to test the representativeness of registration lists, but the self-selection bias assumed to exist in wilderness registration lists (Jubenville 1971; Brown and Haas 1980) does not appear to be large in the case of the Washakie. This result may be partially explained by the particularly well maintained registration system in the southern Washakie.

Table 5.--Option value by income

Group	n	Percent of respondents	Mean option value in $
Wilderness group			(0.93;0.460)[1]
<$10,000	13	8.6	65.38
$10,000-14,999	10	6.6	42.20
$15,000-19,999	13	8.6	51.92
$20,000-29,999	38	25.3	28.42
$30,000-49,999	48	32.0	52.46
$50,000 +	24	16.0	37.54
Urban group			(0.86;0.500)
<$10,000	24	7.8	8.58
$10,000-14,999	20	6.5	5.00
$15,000-19,999	36	11.8	6.17
$20,000-29,999	77	25.2	7.57
$30,000-49,999	95	31.1	8.89
$50,000 +	28	9.2	14.53
Rural group			(1.08;0.370)
<$10,000	12	13.9	.08
$10,000-14,999	13	15.1	4.61
$15,000-19,999	7	8.1	10.71
$20,000-29,999	17	9.7	5.88
$30,000-49,999	24	27.9	6.04
$50,000 +	7	8.1	3.57

[1](Value of F; 2-tail probability)

Table 6.--Selected characteristics of the on-site visitors (in percent)

Characteristics	Washakie visitors: Direct contact	Washakie visitors: Registration list	Characteristics	Washakie visitors: Direct contact	Washakie visitors: Registration list
Age			Occupation		
<20 years	1.8[1]	2.4	Professional	50.9	43.0
20-29 years	31.8	23.6	Business owner	3.5	15.1
30-39 years	28.3	35.4	Skilled	8.8	16.1
40-49 years	21.3	17.9	Sales	7.0	2.2
50-59 years	9.0	14.3	Office worker	1.8	1.1
60-69 years	3.6	6.0	Unskilled	1.8	10.8
70-79 years	0	1.2	Housewife	0	1.1
>80 years	0	0	Retired	5.3	4.3
			Farm	8.8	1.1
Race			Student	8.8	3.2
Black	0	0	Unemployed	0	1.1
Hispanic	0	1.1			
Native American	0	1.1	Sex		
White	96.5	97.8	Female	10.5	14.0
Oriental	0	0	Male	89.5	84.9
Education					
0-8 years	0	0			
9-12 years	15.8	25.9			
13-15 years	21.1	19.4			
16 years	33.3	18.3			
Masters	8.8	23.7			
Doctorate	21.1	11.8			

[1]Columns do not add up to 100 percent because of missing responses

NUMBER OF VISITS BY ON-SITE USERS AND LENGTH OF STAY

The on-site wilderness visitor group visited the Washakie an average of 12.5 times for an average stay of 5.1 days. Figure 3 shows the stratification of option value by the number of visits in the form of a graph. The number of visits is positively related to option value. The positive relationship is highly significant; r = 0.281 (probability = 0.001; n = 150). The relationship between option value and average length of stay is not significant; r = 0.023 (probability = 0.388; n = 150).

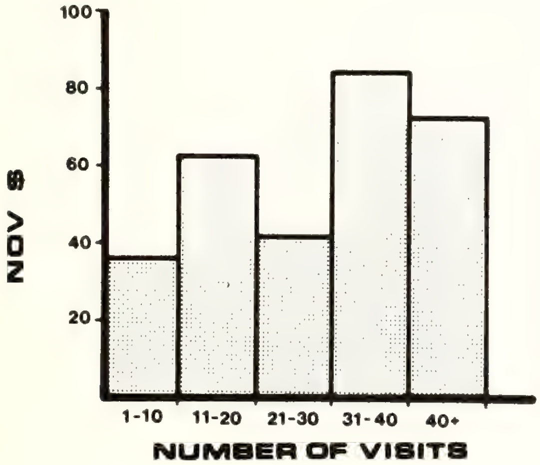

Figure 3.--Net option value by number of on-site visits to the Washakie.

ORGANIZATION MEMBERSHIP AND OPTION VALUE

Table 7 shows option value by respondent membership in sportsmen's, wilderness or environmental organizations. Organization membership resulted in statistically different subpopulation mean option value estimates in only one case: on-site users who are members of wilderness organizations. The cause and effect relationship between organization membership and option value must be interpreted carefully. It is easy to assume that membership is a cause of a higher option value when, in fact, having a high option value might cause membership in organizations that people feel protect a valued feeling for wilderness.

CONCLUSIONS

The results of this research provide some major implications for wilderness management and wilderness resource allocation decisions based on economic efficiency. First, based on the estimates obtained for the Washakie, not a particularly well-known wilderness, option value is an important, nationally held wilderness benefit. It is appropriate to determine the size of option value and include those estimates directly in any economic valuation where estimates of total value of a unit of the NWPS are required. To fail to do so is to accept potentially large underestimates of wilderness benefits.

Table 7.--Option value by organization membership

Membership	Sportsmen's organizations			Wilderness organizations			Environmental organizations		
	Percent responding	Option value in $	t (p)[1]	Percent responding	Option value in $	t (p)	Percent responding	Option value in $	t (p)
Wilderness group									
Yes	26.0	56.97	-1.62	24.7	74.46	-2.70	22.0	59.09	-1.46
No	64.7	34.32	(.111)	68.0	33.03	(.010)*	68.0	37.24	(.152)
Yellowstone									
Yes	20.0	14.37	0.87	15.0	19.16	0.71	15.0	25.83	.50
No	72.5	11.00	(.393)	75.0	10.27	(.483)	75.0	10.62	(.619)
Urban group									
Yes	7.9	15.33	-1.31	4.9	16.66	-1.29	6.6	14.05	-.94
No	90.8	7.27	(.203)	91.8	7.54	(.217)	90.8	7.54	(.356)
Rural group									
Yes	16.3	7.85	-.56	5.8	0	.94	8.1	19.28	-1.05
No	83.7	5.50	(.577)	94.2	6.24	(.348)	91.9	4.69	(.336)

[1]2-tail probability

*Significant at .05 level

However, it is not sufficient to count option value only as a benefit of preservation. This research has demonstrated that option value occurs on the resource development side as well. Even though net option value was positive in the case of the Washakie, values can change over time and be distributed differently for other resource issues.

An equally important set of implications results from the information gained about the distribution of option value in society. Few would have denied the potential for large option values in the on-site wilderness user population. However, quantification of the importance of off-site user option values provides a basis for focusing more detailed study on the relationship between classes of users and the determination of the size of relevant populations in economic valuation studies of the NWPS. Based on the sample of four cities, option value did not diminish to unimportant levels within 1,900 miles of the Washakie. The magnitude of mean option value for an off-site user is only a fraction of that of a on-site user, but the relative size in absolute numbers of the off-site user class makes the cumulative on-site user value seem trivial in comparison. Although more research would be helpful regarding the role of option value in the total economic value of off-site users for the NWPS, at both the national level and its individual areas, it appears that the smallest relevant population when estimating the benefits of designated wilderness is the population of the United States.

Another implication of the importance of the off-site user group is the determination of the optimal level of on-site wilderness use. Wilderness carrying capacity should be set to maintain the integrity of wilderness attributes valued by the off-site user population as well as those of the current on-site users. Research will be needed to determine more fully the attributes that off-site users value. Clearly, if the critical wilderness qualities valued by the off-site users are depreciated by increased on-site use, then much of the value of the NWPS will be at risk. This research shows that more than 55 percent of the option value of both on- and off-site users has nothing to do with current on-site use.

REFERENCES

Barrick, K. Measurement of wilderness benefits and option value, with an application to the Washakie Wilderness, Northwest Wyoming. Carbondale, IL: Southern Illinois University; 1983. 140 p. Ph.D. dissertation.

Bishop, R. Option value: An exposition and extension. Land Econ. 58: 1-15; 1982.

Bishop, R.; Heberlein, T.; Kealy, M. Contingent valuation of environmental assets: comparisons with a simulated market. Nat. Resour. J. 23: 619-633; 1983.

Bohm, P. Estimating willingness to pay: why and how? Scand. J. Econ. 81(2): 142-153; 1979.

Brookshire, D.; Crocker, T. The advantages of contingent valuation methods for benefit-cost analysis. Public Choice. 36(2): 235-251; 1981.

Brookshire, D.; Thayer, M.; Schulze, W.; d'Arge, R. Valuing public goods: a comparison of survey and hedonic approaches. Am. Econ. Rev. 72: 165-177; 1982.

Brookshire, D.; Eubanks, L; Randall, A. Estimating option prices and existence values for wildlife resources. Land Econ. 59: 1-15; 1983.

Brown, P.; Haas, G. Wilderness recreation experiences: the Rawah case. J. Leisure Res. 12: 229-241; 1980.

Cicchetti, C.; Freeman, A. Option demand and consumer surplus: further comment. Quart. J. Econ. 85: 528-539; 1971.

Fischer, D. Willingness to pay as a behavioral criterion for environmental decision-making. J. Environ. Manage. 3: 29-41; 1975.

Greenley, D.; Walsh, R.; Young, R. Option value: empirical evidence from a case study of recreation and water quality. Quart. J. Econ. 96: 658-673; 1981.

Jubenville, A. A test of differences between wilderness recreation party leaders and party members. J. Leisure Res. 3: 116-119; 1971.

Randall, A; Hoehn, J.; Brookshire, D. Contingent valuation surveys for evaluating environmental assets. Nat. Resour. J. 23: 635-648: 1983.

Rowe, R.; Chestnut, L. Valuing environmental commodities: revisited. Land Econ. 59: 404-410; 1983.

Schulze, W.; D'Arge, R.; Brookshire, D. Valuing environmental commodities: some recent experiments. Land Econ. 57(2): 151-172; 1981.

Szorek, G. A definitive guide to selecting test markets. Vol. II. Erie, PA: Times Publishing Co.; 1979.

Thayer, M. Contingent valuation techniques for assessing environmental impacts: Further evidence. J. Environ. Econ. Manage. 8: 27-44; 1981.

U.S. Department of Commerce, Bureau of Census. 1980 Census. Washington, D.C.: U.S. Department of Commerce, Bureau of Census; 1980.

U.S. Department of Agriculture, Forest Service. Oil and gas exploration and leasing within the Washakie Wilderness. UDSA-FS-02-00-81-09. Cody, WY: U.S. Department of Agriculture, Forest Service, Shoshone National Forest; 1981.

Walsh, R; Loomis, J.; Gillman, R. Valuing option, existence, and bequest demands for wilderness. Land Econ. 60: 14-29; 1984.

Weisbrod, B. Collective-consumption services of individual-consumption of goods. Quart. J. Econ. 77: 471-477; 1964.

APPENDIX

After providing appropriate orientation to the participant, the contingent questionnaire began with a description of the Washakie Wilderness including information on the location, size, wilderness character and recreation activities allowed. Consumer surplus for the Washakie as "wilderness" in its present form was estimated with the following question:

Suppose the only way the Washakie could be maintained as wilderness was for people like yourself to contribute to a fund for its protection. What is the maximum amount you would pay into such a fund per year to continue the same level of wilderness protection that the Washakie currently receives under the Wilderness Act?

$\$$____________ PER YEAR

Following the estimate of value for the Washakie as wilderness, the participants were asked to consider a description of oil and gas development proposals, including: a description of leasing provision, number of lease applications, and a brief summary of the positive and negative economic and environmental impacts that were likely. The respondents were then asked to choose between a vector spanning the development, and on to the preservation extreme. The choices were as follows:

______ OIL AND GAS BE PRODUCED AS SOON AS POSSIBLE.

______ OIL AND GAS BE PRODUCED AS SOON AS POSSIBLE, BUT ONLY ON THE PORTION OF THE WILDERNESS WHERE THE EFFECTS WILL BE EASILY MANAGED AND REPAIRED.

______ OIL ANG GAS PRODUCTION BE POSTPONED UNTIL NEW PRODUCTION TECHNOLOGIES GREATLY REDUCE THE EFFECTS ON THE WILDERNESS ENVIRONMENT.

______ OIL AND GAS PRODUCTION BE ALLOWED ONLY IN THE EVENT OF A NATIONAL EMERGENCY.

______ AVOID ALL OIL AND GAS PRODUCTION IN THE WILDERNESS.

(Note: The value responses to the first two choices were aggregated and reported in the results as development option value. The remaining three choices were aggregated and reported as preservation option value.)

Having made a choice regarding preference for the future of the Washakie, a question was given to estimate the value of an "option" that would guarantee the outcome of the preference:

If, as a private citizen, you had the opportunity to contribute to a fund established with a reputable organization that would guarantee the outcome you have chosen above, would you be willing to help pay for the guarantee if you knew that your money would be returned if not enough funds were collected?

______ NO
______ YES
______ YES, BUT ONLY IF (SPECIFY)

Those who valued the option were asked to state their option value:

What is the maximum amount you would be willing to pay into the fund per year?

$\$$____________ PER YEAR

In order to estimate the proportion of option value that the respondents placed on each of the four selected value motives, they were asked to rate the following choices:

- ______ BECAUSE THEY MIGHT WANT TO PERSONALLY VISIT THE WASHAKIE WILDERNESS SOMEDAY.

- ______ BECAUSE THEY GET SATISFACTION IN KNOWING THAT OTHER PEOPLE CAN VISIT THE WASHAKIE WILDERNESS REGARDLESS OF THEIR OWN INTENTIONS FOR VISITING.

- ______ BECAUSE THEY WANT THE WASHAKIE WILDERNESS TO BE AVAILABLE FOR FUTURE GENERATIONS.

- ______ BECAUSE THEY WANT THE WASHAKIE WILDERNESS TO EXIST, JUST SO THEY "KNOW ITS THERE," REGARDLESS OF ANYONE VISITING IT.

The percent of option value attributed to each of these four motives was estimated by asking the respondents to spend 10 one-dollar bills as they wished among the values. A question later in the questionnaire requested estimates directly in percentages and was used as a consistency check.

(complete questionnaire included in Barrick 1983)

Section 9. Wilderness Management Concepts and Tools Research

MANAGEMENT CONCEPTS AND TOOLS--A BROAD TOPIC

Robert E. Manning
Session Coordinator

The session on Management Concepts and Tools was, by definition, quite broad. Conference organizers defined the topic as including "research on concepts and tools that deal with problems in wilderness management and planning." The broad nature of the topic resulted in the largest number of submissions and presentations and required the session to be divided into two concurrent sessions and a poster session.

The concurrent sessions were organized on a thematic basis. The first session was entitled Wilderness Planning with papers divided into two groups: concepts and applications. The papers dealing with concepts of wilderness planning (Ashor, Stokes, and McCool; Graefe, Kuss and Loomis; Manning) discuss the theoretical basis of wilderness planning. Each paper relies on review and synthesis of wilderness research to suggest concepts and methods by which wilderness planning might be conducted. The second group of papers (Parsons; van Wagtendonk; Kania; Boteler) focuses on site-specific applications of wilderness planning. Each paper describes an applied attempt at wilderness planning to ensure that wilderness use does not exceed carrying capacity.

The two groups of papers in this session present an interesting contrast. The conceptual papers are quite broad suggesting a variety of environmental, social, and managerial factors be included in wilderness management planning. The applied papers are considerably narrower, focusing on only a few more tangible and readily available factors, such as historic use levels, physical site impacts, and public safety considerations.

The contrast between these two groups of papers may lead one to ask if research is considerably ahead of management. Or are managers simply more realistic in their outlook than researchers? Answers to these and other questions might best be determined through forums such as the National Wilderness Research Conference, which gather researchers and managers together in the same room.

The second concurrent session was entitled Wilderness Management and focused on the use of information in wilderness management. The first group of papers in this session (Chilman; Rowell; Martin) describe information and information systems designed to assist wilderness managers: a monitoring system, a wilderness use simulation model, and a survey of visitor attitudes toward fee policies. The second group of papers (Schomaker and Lime; Dowell and McCool; Huffman and Williams) explore and evaluate the use of information as a tool for wilderness management. All three studies report encouraging results, suggesting that information dissemination can be an effective as well as a desirable management practice.

Finally, two poster papers from the Management Concepts and Tools session were included with the larger poster session of the overall conference. The paper by Stankey and Clark explores the relationship between timber management and wilderness recreation while the Huppert and Wheeler paper suggests giving added consideration to caves as a resource worthy of wilderness designation and management.

The writer would like to credit several people for their assistance in organizing this session. Three conference coordinators--Glenn Haas, Bob Lucas, and Mike Manfredo--were especially helpful in providing needed guidance. Dan Stynes, Bill Hammitt, Bo Shelby, and Skip Echelberger reviewed and evaluated all abstracts submitted for the session. Bob Muth moderated the second concurrent session. Finally, appreciation is expressed to authors of the papers printed in this section of the proceedings. All authors carefully prepared and presented their papers and provided technical reviews of each other's papers as well.

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IMPROVING WILDERNESS PLANNING EFFORTS: APPLICATION OF THE TRANSACTIVE PLANNING APPROACH

Joseph L. Ashor, Stephen F. McCool and Gerald L. Stokes

ABSTRACT: Use of a transactive planning style, as opposed to traditional rational-comprehensive planning, was found to be more effective in promoting dialogue and mutual learning among those affected by this wilderness planning effort. The results suggest new approaches to planning for wilderness managers.

INTRODUCTION

The National Wilderness Preservation System has grown considerably since the passage of the Wilderness Act more than 20 years ago. The importance of management plans that effectively address future as well as current activities in wilderness areas has also grown. Past wilderness planning efforts relied heavily on a technocratic planning approach that included the public in only a peripheral manner. Public involvement was most often relegated to that of "receiver" of information; input was limited to comments about what alternative was favored or what wasn't liked about the plan. Adversarial relationships often developed between the managing agency and the public. Hence, managers and planners were reluctant to directly include citizen participants in their planning efforts for fear of exacerbating this relationship.

Another characteristic of past wilderness planning was the lack of agency awareness of the political environment in which planning occurred. As a result, many controversial decisions were later appealed by interest groups and affected users. This was especially true in primitive river recreation settings (Utter 1979; McCool and Ashor 1985). Litigation, appeals, and political maneuvering were much more prevalent than the public's enthusiastic acceptance (Sorensen 1984). As a result, many plans have never been formally accepted, some accepted have not been implemented, and still others have shied away from controversial decisions. In short, many wilderness planning decisions are inherently political in nature. These decisions can no longer be approached using traditional planning perspectives.

How can wilderness planning be made more effective? How can it be conducted within the context of a politicized setting? Answers to these questions were sought by evaluating a planning process that was undertaken in the Bob Marshall Wilderness Complex (BMWC) in western Montana, a process designed specifically to acknowledge the reality of a politicized environment. Of key concern was the need to involve the public in the decision-making process and to begin tailoring wilderness planning toward participatory democracy and decentralized "bottom up" planning. The process combined a transactive planning approach with the Limits of Acceptable Change (LAC) planning system.

An Alternative Approach: Transactive Planning

Transactive planning, first developed by Friedmann (1973b), arose in response to the deficiencies and problems posed by the synoptic planning approach. The synoptic approach, which relies heavily on comprehensive calculations and models, is the most prevalent form of planning used in our society today. Critics charge that its heavy dependence on numerical calculations and models has left communities, government agencies, and large corporations with an abundance of plans unresponsive to the public's needs and concerns. In our rapidly changing society, with values often in a state of flux, goals and objectives cannot be adequately defined or determined (Braybrooke and Lindblom 1963; Freeman 1974). Synoptic planning's tendency toward elitism, centralization, and resistance to change has made the comprehensive ideal largely unattainable (Grabow and Heskin 1973). This approach also appears in distinct contrast to the "participatory democracy" described by Naisbitt (1982).

The transactive approach, on the other hand, is very decentralized and emphasizes grass-roots involvement of people who may be affected by planning decisions. Friedmann (1973b) views planning as part of a much larger process of societal action and change rather than construction of long-range comprehensive plans. "It is an activity centrally concerned with the linkage between knowledge and organized action" (Friedmann and Hudson 1974). Planning no longer focuses on static quantitative models but instead is viewed as a thinking,

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learning, and continually evolving process. Dialogue, mutual learning, and societal action and guidance are key elements of the transactive planning approach.

Friedmann (1973b) proposes that the first step be face-to-face dialogue between citizens and planners in small intimate working groups. Planners bring to the process technical knowledge, concepts, theories, and data which they share with the citizens. The citizens bring personal knowledge of the planning environment and a keen sense of what is feasible to actually solve the problem(s).

The next phase is the mutual learning that develops from the planning partnership. The positive exchange of information will, over time, lead the group to a mutual understanding and learning about each other's problems and concerns. Friedmann feels this will help narrow the knowledge gap and more easily facilitate actual decisions on a course of action. Because the working group represents all political interests, its decisions are enforceable by various political actors (McCool and Ashor 1985). The final phase of transactive planning is described by Friedmann as societal guidance or action. The concept of societal guidance, originally developed by Etzioni (1968), can be defined as the "process by which the incidence, rate and direction in society are controlled." A society able to guide itself would enable individuals, institutions, and government agencies to adapt to rapidly changing conditions such as those outlined by Toffler (1981) and Naisbitt (1982).

Thus, through dialogue and mutual learning at the local level, planners and citizens can avoid the frustrations of unresponsive centralized planning which often leaves planners "frozen into a pattern which prohibits them from satisfying anybody, and witnessing the wastage of scarce resources on all sides" (Freeman 1974).

The Bob Marshall Wilderness Complex Transactive Planning Process

The BMWC contains a variety of unique ecologic, geologic, and historic characteristics. It also contains a multitude of physical and social management problems that have gone largely unresolved because of poor implementation of past plans. The nine step LAC system, outlined by Stankey and others (1985), was a planning system chosen by managers to begin dealing with key problems such as campsite and range impacts. While LAC is a relatively new planning system, it still can be as unresponsive as past planning approaches if intimate citizen involvement is neglected. Hence, a transactive style of planning was chosen in an attempt to be more responsive to citizen needs.

In early 1982, a task force was formed that consisted of managers, planners, researchers, specialists, users, and concerned citizens. The make-up of the task force included representatives from four National Forests, the outfitting industry, local and national environmental organizations, backcountry horse clubs, Fish Wildlife and Parks personnel, and unaffiliated user groups. The task force was specifically designed to represent a microcosm of the political marketplace (Caulfield 1975; Stokes 1982).

It had the following objectives:

1. To assure authentic, substantive public involvement.

2. To increase public support for the plan, and to hold the agency accountable for implementation.

3. To validate or temper the scientific/theoretical and technical information with the collective personal knowledge of the group.

4. To incorporate additional information not held by the planners.

5. To garner additional monetary and political support for wilderness management.

6. To identify and resolve issues early in the planning process.

7. To develop a sense of shared ownership in the plan.

8. To develop a viable political coalition (Caulfield 1975).

Armed with a new approach to wilderness management planning, the task force began a three and a half year process to produce a new recreation management plan for the BMWC that would not only begin to develop solutions to the myriad of problems that faced the area, but would also create an atmosphere in which the solutions and management actions chosen would be implemented in a comprehensive and timely manner. Since the task force was formed, it has met as a formal group about twice a year. More than 50 small group meetings and presentations to other interested groups have been held with the help of outside consultants.

Testing the Transactive Planning Approach

The primary objective of this study was to test for (1) the occurrence, and (2) the effectiveness of transactive planning as it was applied in the BMWC. To accomplish this task, three methodologies were employed to gather information pertinent to the three elements of transactive planning (dialogue, mutual learning, and societal action).

1. Participant observation - This was conducted throughout the entire planning process. The researchers actually observed the documented key aspects of the planning process that indicated the occurrence of dialogue, mutual learning, and societal action. All of the authors served as participant observers in this study.

2. Theory evaluation surveys - These were administered approximately two-and-a-half years into the process and involved the entire task force, as well as 35 individuals who had recently participated in a wilderness planning effort that had just been completed in the Rattlesnake National Recreation Area and Wilderness, north of Missoula, Montana.

3. Theory evaluation interviews - These were conducted on nine select task force participants who had maintained a high level of involvement throughout the entire BMWC planning process. Each major interest group on the task force, as well as key planners and coordinators, was represented in these interviews, which were conducted near the end of the process.

In order to facilitate analysis of the research data, the critical incident interval approach developed by Stokes (1982) was utilized. The approach divides the planning process into intervals which are determined on the basis of major decision points that occur in the planning process. A determination of five intervals was made on a judgmental basis by the researchers based on their collective knowledge of the planning environment. The actions and activities within each interval were analyzed for dialogue and mutual learning. Finally, the results of all five intervals were summed and evaluated for the occurrence of societal action.

The analysis of dialogue, mutual learning, and societal action was based upon performance indicators suggested by Friedmann for evaluating transactive planning theory (table 1). More detail on the methodology of the evaluation and the critical incident interval approach is provided by Ashor (1985) and Stokes (1982). These indicators were used to determine both the extent to which transactive planning occurred and its effectiveness when compared with a more traditional planning approach used in the Rattlesnake National Recreation Area and Wilderness.

Analysis of Transactive Planning Indicators

To shed some light on the occurrence of transactive planning, the following question was posed: Did the three elements of transactive planning (dialogue, mutual learning, and societal action) occur in this process and, if so, to what extent?

The results of the occurrence of each dialogue indicator and the number of intervals that indicator was found to be present are shown in table 2. Again, the results are based on information gathered through surveys, interviews, and participant observation. The summary results of table 2 reveal that one or more indicators of dialogue was verified for all five intervals, presenting sufficient evidence that dialogue occurred during this planning process.

Table 1.--Performance indicators for dialogue, mutual learning, and societal action

DIALOGUE

1. Authenticity (acceptance of others)
2. Integrated person(s) (whole person displayed by speech and good faith)
3. Conflict acceptance (difference in viewpoint)
4. Communication (conveyance of meaning)
5. Shared interests and commitment (common concern)
6. Reciprocity (mutual obligation)
7. Common time and space (here and now)

MUTUAL LEARNING

1. Planner contributions (processed knowledge)	2. Client contributions (personal knowledge)
a) concept	a) operational details
b) theory	b) realistic alternatives
c) analysis	c) priorities
d) new perspectives	d) norms
e) systematic search procedures	e) feasibility judgments
f) facilitator	

SOCIETAL ACTION

1. Autonomy	4. Effectiveness
2. Responsiveness	5. Efficiency
3. Innovativeness	6. Legitimacy

The summary results of the analysis of mutual learning indicators are shown in table 3. Documentation and evidence were found for virtually all mutual learning indicators in all five critical intervals.

After three years of participating in the process, interviewees were asked the following question: Do you feel mutual understanding and learning about the LAC concept and most of the problems the BMWC faces has been reached by most individuals in the process? All of those interviewed agreed that it had, with most stating that everyone had a much better understanding of each other's views, problems, and concerns. One individual felt mutual learning was the most important thing that had come out of the process.

The indicators of societal action are autonomy, responsiveness, innovation, legitimacy, effectiveness, and efficiency. Each will be discussed briefly to assess the extent of societal action in this process.

Autonomy means the planning system must be able to set its own objectives and pursue them effectively (Friedmann 1973). This was evident in the BMWC planning process in several ways. While the Forest Service did provide the leadership role throughout the process, it did not operate within any formal agency guidelines on how to conduct LAC planning. No direction was given from regional or national office planners. Local agency planners were free to apply planning techniques tailored to meet local needs. A transactive style of planning was intended from the very beginning and, along with the LAC process, provided the basic framework throughout the entire planning effort. Survey and interview results revealed that even though citizens could not have operated in a totally autonomous way, they were still able to pursue their own objectives with agency planners and managers in an informal and productive atmosphere. An interdependent, cooperative relationship existed between managers, planners, and citizens. This often allowed citizens to freely develop solutions and realistic alternatives to problem situations.

The BMWC planning process was responsive because it was able to take into account a variety of specialized interests, needs and values of groups affected by its actions. More than 80 percent of the survey respondents agreed or strongly agreed the planning process was responsive. An open-ended question on the theory evaluation survey relating to successes of the process revealed numerous statements confirming the responsiveness of the process.

Table 2.--Summary of confirmation/occurrences for dialogue in the Bob Marshall Wilderness Complex

Dialogue Indicator	Interval confirmation[1/] Present	Not Present	Insufficient
Authenticity	3	1	1
Integrated persons	4	1	-
Conflict acceptance	2	1	2
Communication	5	-	-
Commitment	4	-	1
Reciprocity	4	-	1
Common time and space	5	-	-

1/ Number of intervals dialogue indicator was found to be present/not present or lacked sufficient evidence and/or adequate documentation.

Table 3.--Summary of confirmation/occurrence for mutual learning in the Bob Marshall Wilderness Complex Planning Process

Mutual Learning Indicator	Interval confirmation[1/] Present	Not Present	Insuff.
Planner Contrib.			
Concept	5	-	-
Theory	5	-	-
Analysis	5	-	-
New perspective	5	-	-
Systematic search procedures	5	-	-
Facilitator	5	-	-
Client Contrib.			
Operational details	5	-	-
Realistic alternatives	5	-	-
Priorities	5	-	-
Norms	4	-	1
Feasibility judgments	5	-	-
Receptiveness	5	-	-

1/ Number of times mutual learning indicator was found to be present/not present or lacked sufficient evidence and/or adequate documentation.

- It is grounded more in reality than past plans.

- The Forest Service made a sincere effort to listen to citizen concerns.

- Citizen ideas and concerns were incorporated into the plan.

The entire planning process was a case study in innovative wilderness planning. Not only was the transactive style of planning a new and innovative way of approaching Forest Service planning, but the nine-step LAC system had never been tried before. Because of this first time application of both LAC and transactive planning in a highly politicized environment, innovative techniques for solving many of the problem situations were frequently used. The facilitation of the process by planners not employed by the agency represented another major innovative characteristic of the process. All of those interviewed strongly agreed that transactive planning was an innovative approach and a great improvement over traditional Forest Service planning approaches.

The BMWC planning process was also effective because it created a heightened awareness of the various problems among all groups involved and had definitely tempered passions, ultimately allowing a working relationship among managers, researchers, planners, and citizens. Open-ended responses from the survey revealed that participants felt the process was effective in . . .

- Providing a vehicle for a dynamic, ongoing process rather than a static management plan.

- Showing Forest Service management and political problems to citizen participants.

- Improving coordination between Forest Service administrative units.

- Involving a representative range of public and user groups as active participants.

- Breaking new ground for future wilderness planning that involves LAC and transactive planning.

The fiscal efficiency of the process was shown in many ways. First and foremost was the tremendous amount of time and energy devoted to the process by citizen participants. The personal and even technical knowledge provided by users and citizens greatly aided managers and planners and strengthened the overall plan. The feasibility of many planned actions could be checked continually, thereby avoiding inefficient and politically costly decisions. Public support and ownership reduced the probability of costly appeals over controversial management actions or implementation. The hiring of outside assistants to coordinate and facilitate the process was also far more fiscally efficient than employment of comparable agency planners (Flathead National Forest Plan coefficient documentation, appendix E-1AB 1981).

A legitimate planning system must inspire loyalty and be capable of mobilizing popular support for its actions (Friedmann 1973b). Study results showed that as knowledge about the LAC system and its application increased among planning participants, loyalty and support increased as well. Once people understood the LAC process and its interrelationship with a transactive style of planning, their support and loyalty to the process, in most cases, quickly followed. By the end, many citizens had developed a sense of shared ownership, as evidenced by the many times they defended the plan as "theirs" and voiced support for the LAC process and the public involvement approach being used.

The Effectiveness of Transactive Planning

How much more effective is transactive planning than a more traditional synoptic approach? In order to explore the effectiveness of transactive planning as applied in the BMWC, two theory evaluation surveys were conducted. The first, already mentioned, was administered to all BMWC task force members in May 1984. It was intended to measure the success of the planning effort up to that point. The second survey was administered a few months later to a random sample of citizens who had recently completed participation in the planning process for the Rattlesnake National Recreation Area and Wilderness (RNRAW).

The public participation program for the RNRAW was similar to many traditional approaches being used throughout the Forest Service at that time. Issues and problems were identified and workshops held with interested public groups. A proposed range of management alternatives was presented and the public was invited to comment. Although many meetings were held, and new and innovative ways of collecting the public's major concerns were tried, no task force was ever formed to initiate dialogue in a form recommended by Friedmann (1973b).

Respondents were asked to evaluate 17 statements about the planning process that tested for the indicators of the three elements of transactive planning. Fifty surveys were sent to RNRAW participants; 35 were returned, for a response rate of 70 percent. Thirty-six members, or about 90 percent of the BMWC task force, participated in the planning survey.

Each respondent was asked to indicate the extent to which they agreed or disagreed on a five-point Likert scale (1 indicating "strongly agree", 5 "strongly disagree"). A nonparametric Wilcoxon Rank Sum Test was used to test for significant differences between the responses from the two planning situations.

Results for dialogue are shown in table 4. First, note the mean ranks for each indicator for the BMWC planning process are less than or equal to the mean ranks for the RNRAW planning process. Lower mean ranks better signify the positive verification of that indicator, that is, a higher percentage of respondents agreeing with a particular statement. Shared interest and commitment and a relationship of mutual obligation were much stronger in the BMWC process. These results show that dialogue was present in the BMWC planning process in a stronger way than in the RNRAW process.

When examining the mean ranks for mutual learning in table 5, one can see that all of them are lower in the BMWC situation. Statistically significant differences at $\alpha = .05$ are found in the two statements relating to the occurrence of mutual learning in general and the use of personal knowledge in the planning process. Therefore, the BMWC transactive planning process was more effective in promoting mutual learning than the approach used in the RNRAW.

The mean ranks for the indicators associated with societal action show very little difference between the two planning situations. This may be due in part to the incomplete nature of the BMWC transactive planning process at the time the survey was conducted. Results do show the BMWC process was more responsive and better able to take into account the various groups' interests, needs and values. In order to summarize the results, grand mean ranks for each dimension of transactive planning were calculated (table 6). The overall results show that the transactive planning process used in the BMWC was able to bring about dialogue and mutual learning much more effectively than the synoptic approach used in the RNRAW.

Table 4.--Transactive planning dialogue statements indicators and mean ranks for a Wilcoxon Rank Sum Test of significiant between the BMWC and RNRAW planning processes

Statement	Indicator	BMWC[1/]	RNRAW[2/]	p[3/]
1. I feel my views were readily accepted by the diverse makeup of individuals involved in the planning process.	Authenticity	29.0	38.9	0.0128*
2. Comments in all meetings by most participants were in most cases conveyed sincerely and in good faith.	Integration of person	28.8	37.3	0.0238*
3. Comments in all meetings by most participants were in most cases conveyed in an open manner.	Integration of person	28.7	37.4	0.0170*
4. All parties involved in the planning process have for the most part accepted the differing viewpoints of others.	Conflict Acceptance	29.0	38.8	0.0170*
5. All participants that were involved in the planning process for the most part accepted the right of others to express opposing views.	Conflict Acceptance	29.8	36.0	0.0515
6. The concerns of the majority of citizens were incorporated into the management plan.	Communication	29.3	35.4	0.0767
7. There was a shared interest and commitment among all parties involved in the planning process to produce a plan that would adequately begin to address recreation management in the area.	Commitment	26.8	41.6	0.0004*
8. A relationship of mutual obligation and reciprocal "give and take" existed between those involved in the planning process.	Reciprocity	26.6	41.0	0.0003*
9. Adequate consideration was given in the alternatives presented to represent the views of all interested citizens.	Common time and space	35.0	35.0	0.4948

1/ Bob Marshall Wilderness Complex
2/ Rattlesnake National Recreation Area and Wilderness
3/ 1 tailed probability corrected for ties
*Statistically significant difference at $\alpha = .05$

Management Implications and Conclusions

What do these results and the experiences in the BMWC planning effort signify to managers? First and foremost is a transactive style of planning, if used properly, can improve acceptance and support of wilderness plans by users and interested citizens. This is especially critical when sophisticated management systems such as LAC are employed in areas with controversial and politically volatile issues. Implementation is more

Table 5.--Transactive Planning mutual learning and societal action statements, indicators and mean ranks for a Wilcoxon Rank Sum Test of significance between the BMWC and RNRAW planning processes

Statement	Indicator	BMWC[1/]	RNRAW[2/]	p[3/]
MUTUAL LEARNING:				
1. Knowledge gained about the planning process from other citizens or managers has better enabled me to be a more effective participant.	Transfer of Knowledge	31.2	38.2	0.0541
2. Mutual learning about most aspects of the planned process occurred among most of those involved.	Mutual learning	20.9	48.0	0.0000*
3. My personal knowledge of the area has been utilized in the planning process.	Personal knowledge	26.9	40.6	0.0010*
SOCIETAL ACTION:				
1. Citizens were able to set their own objectives for the plan and pursue them effectively.	Autonomy	31.8	36.6	0.1363
2. Citizens, users of the area and other concerned publics are able to plan for themselves.	Autonomy	30.9	33.4	0.2818
3. The planning process was responsive and able to take into account a variety of specialized interests, needs and values of groups affected by its actions.	Responsiveness	30.9	37.5	0.0566
4. The planning process was able to develop viable alternatives to new problem situations.	Innovation	34.1	31.7	0.2841
5. The planning process was capable of mobilizing popular support for its actions.	Legitimacy	35.6	28.7	0.0553

1/ Bob Marshall Wilderness Complex
2/ Rattlesnake National Recreation Area and Wilderness
3/ 1 tailed probability corrected for ties
*Statistically significant differences at $\alpha = .05$

likely if managers have the support of wilderness users who feel a sense of "ownership." This is based on the notion that in many wilderness areas, planning is ultimately a political rather than a technical process (Stankey and others 1984). While the technical skills of managers are still vital, an awareness of the needs, values, and beliefs of the various concerned interest groups should be a part of the planning process as well (Naisbitt 1982).

Not all wilderness areas are as controversial in nature as the BMWC. In those that are, transactive planning will not necessarily decrease the controversial nature of the many issues that face today's managers. However, the effective use of transactive planning principles suggests that by bringing citizens and users into the process at its inception, issues can be identified and addressed early.

The fact remains that conflict over wilderness planning and management will continue unless managers are willing to dedicate themselves to meaningful citizen participation. Veto power in the hands of affected groups makes transactive planning a necessity in many areas. The goal of such a process is not only to increase support and the chance of successful implementation, but to create a process for decision making that affected groups will accept as legitimate, even when their demands may not be entirely met (Irland 1975).

Using a transactive style of planning is not without its costs and potential dangers. Managers must be aware of building false hopes which the planning process may not be able to fulfill. This type of process also requires time and affort that may extend the length of the process, thereby increasing salary costs (Aleshire 1970). This style of planning also depends in large part on skills new to wilderness managers. They would need skill in managing interpersonal relations and have an awareness of how they relate to others. An increased capacity for learning special skills, an ability to live with conflict, and an understanding of the dynamics of power are among the variety of skills needed to carry out successful transactive planning (Friedmann 1973a).

Table 6.--Wilcoxon Rank Sum Test. Mean ranks and probability scores on transactive planning dimensions by planning situation

DIMENSION	BMWC[1/]	RNRAW[2/]	p[3/]
Dialogue	28.4	42.2	0.0021*
Mutual Learning	23.7	46.6	0.0000*
Societal Action	33.6	34.4	0.4372

[1/] Bob Marshall Wilderness Complex

[2/] Rattlesnake National Recreation Area and Wilderness

[3/] 1-tailed probability corrected for ties

*Statistically significant differences at α = .05

In summary, the results of this study show that transactive planning was present in the BMWC process and was more effective in promoting dialogue and mutual learning than the synoptic approach utilized in the RNRAW planning effort. The results of the study also strongly suggest that successful implementation of the LAC management system in the BMWC will require ongoing public involvement. For an untried system such as LAC, the flexibility must remain to alter and refine the system as various aspects are evaluated. As controversial management decisions and changes are made, politically prudent managers would find it to their advantage to continue a dialogue with affected groups at least on a biannual basis. Maintaining the viable political coalition needed to support the management actions they may be implementing is crucial if the wilderness resource is to be truly protected.

Finally, transactive planning needs to be applied and tested for its effectiveness in a variety of wilderness settings. More research needs to be conducted into the kinds of personalities that would make successful transactive planners. Researchers need to more precisely determine the types of people who are most likely to actively serve on a task force. Also important would be further research aimed at testing the legitimacy and effectiveness of the indicators this study has utilized as well as what kinds of situations promote and enhance the occurrence of these indicators. By expanding upon the knowledge gained from numerous applications of transactive planning, researchers can begin developing guidelines and criteria that could aid managers and planners in applying this style of planning in a wide variety of wilderness settings.

REFERENCES

Aleshire, Robert A. Planning and citizen participation: Costs, benefits and approaches. Urban Affairs Quarterly. 5(4): 369-393; 1970.

Ashor, Joseph L. Recreation management in the Bob Marshall Wilderness Complex: An application of the limits of acceptable change concept and transactive planning theory. Missoula, MT: University of Montana; 1985. 224 p. M.S. Thesis.

Braybrooke, David; Lindblom, Charles E. A strategy of design. New York: The Free Press; 1963.

Caulfield, Henry P., Jr. Politics of multiple objective planning. In: Proceedings of the multiple objective planning and decision making conference, Boise ID: (published by the Idaho Research Foundation, Inc., Moscow, ID.); 1975.

Etzioni, Amitai. The active society. New York: The Free Press; 1968.

Freeman, David M. Technology and society: issues in assessment, conflict and choice. Chicago: Rand McNally College Publishing Co.; 1974. 112 p.

Friedmann, John. Notes on societal action. Journal of the American Institute of Planners. 35(5): 311-318; 1969.

Friedmann, John. The public interest and community participation: toward a reconstruction of public philosophy. Journal of the American Institute of Planners. 39(1): 2-12; 1973a.

Friedmann, John. Retracking America. Garden City, NJ: Anchor Press/Doubleday; 1973b.

Friedmann, John; Hudson, Barclay. Knowledge and action: a guide to planning theory. Journal of the American Planning Association. 45(2): 180-189; 1974.

Grabow, Stephen; Heskin, Alan. Foundations for a radical concept of planning. Journal of the American Institute of Planners. 39(2): 106; 1973.

Irland, Lloyd C. Citizen participation--a tool for conflict management on the public lands. Public Administration Review. 35, May/June, 263-269; 1975.

McCool, Stephen F.; Ashor, Joseph L. Politics and rivers: creating effective citizen involvement in decision making. In: Proceedings of the 1984 national river recreation symposium; Baton Rouge, LA: Louisiana State University; 1985.

Naisbitt, John. Megatrends: ten new directions transforming our lives. New York: 1982. 290 p.

Sorensen, Martin. Appeal of White River Forest Plan (Appeal No. 1123); December 20, 1984.

Stankey, George H.; McCool, Stephen F.; Stokes, Gerald C. Limits of acceptable change: a new framework for managing the Bob Marshall Wilderness Complex. Western Wildlands. 10(3): 33-37; 1984.

Stankey, George H.; Cole, Dave N.; Lucas, Robert B. and others. The limits of acceptable change (LAC) system for wilderness planning. General Technical Report INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

Stokes, Gerald L. Conservation of the Blackfoot River Corridor--an application of transactive planning theory. Fort Collins: Colorado State University; 1982. 229 p. Ph.D. Dissertation.

Toffler, Alvin. The third wave. New York, N.Y.: Bantam Books; 1981.

Utter, Jack. Wild river management: a case study of the Use Application Issue. Missoula: University of Montana; 1979. 305 p. Ph.D. Dissertation.

VISITOR IMPACT MANAGEMENT IN WILDLAND SETTINGS

Alan R. Graefe, Fred R. Kuss, and Laura Loomis

ABSTRACT: This paper demonstrates a process for the effective management and reduction of visitor impacts in backcountry recreation settings. The proposed process, derived from previous research and management experience, involves an eight step sequence of tasks designed to facilitate the identification of problem conditions (or unacceptable impacts), the determination of potential causal factors affecting the occurrence and severity of unacceptable impacts, and the selection of potential management strategies for ameliorating the unacceptable conditions. This process may be integrated with existing agency planning efforts or may be applied as a management tool for assessing and managing localized visitor impact problems. A case study from Great Smoky Mountains National Park is used to illustrate the Visitor Impact Management (VIM) framework.

INTRODUCTION

The burgeoning recreational use of backcountry areas during the past 20 years has been accompanied by a comparable growth of research and writing related to backcountry visitor management. The management process demonstrated here is the final component in a study whose overall objectives were: (1) to summarize and synthesize the existing theoretical and empirical literature related to recreational impacts and carrying capacities; and (2) to apply the resulting understanding to the development of a framework or process for visitor impact management which is applicable across a variety of types of settings. Project results were developed through a three year study period which involved review of relevant published and unpublished literature as well as field visits to selected National Park sites. The complete results of the study are reported in three documents published by the National Parks and Conservation Association, the sponsor of the research. These reports include a synthesis of ecological and social research (Kuss and others 1986), a bibliography and descriptive analysis of the carrying capacity/recreation impacts literature (Drogin and others 1986), and a handbook for managers providing a complete description of the visitor impact management framework (Graefe and others 1986). This paper summarizes study results and illustrates a process through which visitor impacts upon vegetation, soils, water quality, wildlife and the visitor experience can be evaluated and managed in an integrated manner that incorporates the principles of recreational carrying capacity derived from current theory and study.

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THE VISITOR IMPACT MANAGEMENT FRAMEWORK

The goal underlying the products of this research is to provide a variety of types of information to assist planners and managers with the difficult task of managing undesirable visitor impacts. Another goal of the project is to suggest approaches to management that reflect current scientific understanding of the nature and causes of visitor impacts and that build upon previous management strategies that have been proposed for dealing with visitor impacts and carrying capacities.

Scientific Basis for Management

Our review of the scientific literature related to carrying capacities and visitor impacts concluded that there are five major sets of considerations that are critical to understanding the nature of recreation impacts:

1. Impact Interrelationships: There is no single, predictable environmental or behavioral response to recreational use. Instead, an interrelated set of impact indicators can be identified. Some forms of impact are more direct or obvious than others, but any impact indicator or combination of indicators could become the basis for a management strategy or capacity determination.

2. Use-Impact Relationships: The various impact indicators are related to varying levels of use intensity, although the strength and nature of the relationship varies widely for different types of impacts. Most impacts do not exhibit a direct linear relationship with user density. Use-impact relationships are influenced by many aspects of use intensity and a variety of situational factors.

3. Varying Tolerance to Impacts: One of the most important factors affecting use-impact relationships is the inherent variation in tolerance among environments and user groups. All organisms and recreationists do not respond in the same way to encounters with visitors. Some may benefit at the expense of others who are injured or displaced.

4. Activity-Specific Influences: Some recreational activities create impacts faster or to a greater degree than other types of activity. Impacts can vary even within a given activity according to type of transportation or equipment used and visitor characteristics such as party size and group behavior.

5. Site-Specific Influences: The impacts of recreation are influenced by a variety of site-specific and seasonal variables. That is, given a basic tolerance level to a particular type of recreation, the outcome of recreational use may still depend on the time and place of the human activity.

These five issues represent important management considerations regardless of the type of impact at hand. That is, these considerations apply whether one is focusing on physical, ecological or social impacts.

The Visitor Impact Management Process

The following discussion describes an approach to resource management that incorporates the aforementioned scientific considerations within a sequential process aimed at reducing or controlling the impacts that threaten the quality of outdoor recreation areas and experiences (figure 1). The steps in this process are designed to facilitate dealing with three basic issues inherent to impact management: (1) the identification of problem conditions (or unacceptable visitor impacts); (2) the determination of potential causal factors affecting the occurrence and severity of unacceptable impacts; and (3) the selection of potential management strategies for ameliorating the unacceptable conditions. Special attention is paid to illustrating the integration of management and research, including making use of existing data sources as well as identifying the most critical research questions.

The VIM process builds upon the widely accepted notion that effective management involves both scientific and judgmental considerations (Hendee and others 1978; Stankey 1980; Shelby and Heberlein 1984). Effective management is also more than carrying capacities and use limits (Washburne 1982). While use quotas represent one possible strategy for reducing the impacts of visitors, it is important to remember the lessons from previous studies that found only weak or indirect relationships between impacts and overall use levels (Graefe and others 1984; Kuss and others 1986). In such instances, establishing capacities and limits may do little to reduce the impact problems they were intended to solve, whereas other potential management strategies may be quite effective for reducing the impact conditions.

<u>Step 1: Preassessment Data Base Review</u>.--The first step in the process involves compiling and reviewing pertinent existing information. The amount of relevant material may vary from situation to situation, but there will inevitably be <u>some</u> background information that can be used to establish an initial perspective on the problem. Policy documents and plans (agency-wide and local) may include useful information as well as management guidance or constraints. Area records and previous visitor surveys may provide baseline data on visitor characteristics, motivations, and participation patterns within the area. The real objective of Step 1 is to identify and summarize what is already known about the area in question so that existing information can be put to its best use as the process continues.

During the preassessment data base review, it will be necessary to delineate the physical area to be included throughout the visitor impact management process. For convenience, visitor management areas could be patterned after management zones already in place. In other instances, it may be desirable to define visitor management sub-units within existing management zones. What is most important is to identify an area that is workable from a management standpoint and that encompasses the zone of influence over the impact situation under consideration.

<u>Step 2: Review of Management Objectives</u>.--The second step in the process is to review management objectives pertinent to the situation at hand. In recent years, several authors have emphasized the importance of clear and specific management objectives (Brown 1977; Hendee and others 1978). To be effective, management objectives need to define the type of experience to be provided in terms of appropriate ecological and social conditions (Stankey 1980).

<u>Step 3: Selection of Key Impact Indicators</u>.--The third step in the process involves identifying measurable indicators for the pertinent management objectives. Once objectives have described the type of environmental conditions and visitor experience to be provided, this step serves to identify how the specified conditions and experience will be measured. The specific decision required here is the selection of the most important variables or attributes to serve as indicators of the desired conditions.

It is important to recognize that there is no single indicator or set of indicators that is appropriate for all situations. The choice of indicators depends upon the particular types of impact under consideration and the specific characteristics of the site. Several criteria can be used, however, to evaluate the potential usefulness of alternative indicators. Useful indicators will include those that are directly observable, relatively easy to measure, directly related to the objectives for the area, sensitive to changing use conditions and amenable to management.

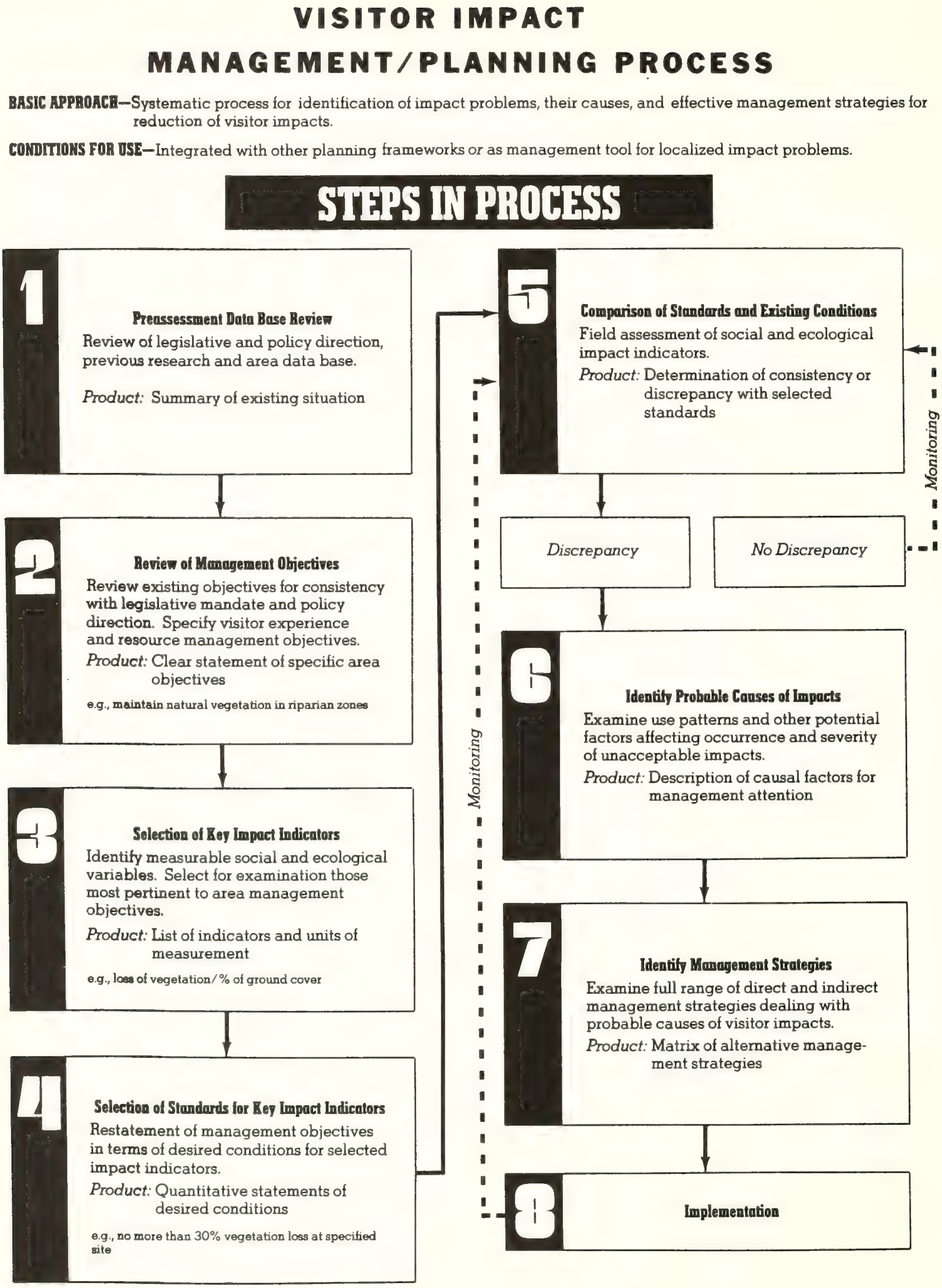

Figure 1.--The visitor impact management planning process.

Step 4: Selection of Standards for Key Impact Indicators.--Step 4 adds one further layer of specificity to the VIM process by calling for standards for the previously selected impact indicators. This step, in essence, calls for a restatement of management objectives in quantitative terms. Standards differ from management objectives by specifying appropriate levels or acceptable limits for the impact indicators designated in Step 3. The standards selected become the basis against which the existing situation is evaluated. Thus, this step serves the important function of describing the environmental conditions and type of experience to be provided in units of measurement which are compatible with available measures of the situation that currently exists.

Step 5: Comparison of Standards and Existing Conditions.--After the first four steps in the process have clarified the conditions one is trying to achieve in a given area, the existing situation can be compared to this desired state of affairs. This step requires an inventory and assessment of current conditions for those impact indicators that were selected in Step 3. This assessment does not necessarily require elaborate and costly studies. What is necessary, however, is a level of observation and measurement that provides for a reasonable comparison of existing conditions and their corresponding standards.

If there is no discrepancy between current measures of pertinent indicators and corresponding standards, one needs only to monitor the situation for future changes. In this instance, the area is currently providing the environmental conditions and type of experience that have been defined as appropriate for the area. The monitoring that is done, however, should include both the impact indicators that are most susceptible to future changes and the use patterns that may lead to changes in the status of these impact indicators. Collection of this data prior to the time problem conditions are identified will allow analyses of use/impact relationships which may reveal the probable causes of future discrepancies between site conditions and standards.

If current measures for certain indicators do not meet the standards for the area, a problem situation is documented. It is then appropriate to move on to the identification of probable causes of the unacceptable impacts.

Step 6: Identification of Probable Causes of Impacts.--Because of the many potential factors that may contribute to impact conditions, the challenge of Step 6 is to isolate the most significant cause(s) of the problem situation. This task can be approached by examining the relationships between visitor use patterns and the impact indicators that have exceeded their respective standards. In examining potential causal factors, it is important to consider the full range of specific aspects of visitor use that may influence the situation, including type of use, length of stay, size of groups, time of use, concentration of use, frequency of high use periods, overall amount of use, and behavior of visitors. It is also important to remember that use/impact relationships may be mediated by site characteristics and consequently may vary for different times and places.

Step 7: Identification of Management Strategies.--With some understanding of how the amount, type and distribution of people using a given area affect the quality attributes of the area and experience, it is possible to identify a range of alternative management strategies. Just as many aspects of use may contribute to the problem, many management alternatives are available for dealing with the problem. It is important at this phase to focus on the probable causes of the visitor impacts rather than on the impact conditions themselves. It is also important to recognize that one may never have complete understanding of the causes underlying certain visitor impacts, nor can one predict exactly how a given management action will affect a particular problem situation.

Management techniques aimed at reducing a particular impact problem may adversely affect other aspects of the situation or may introduce other problems for managers. For this reason, a matrix approach for evaluation of alternative management strategies is recommended (see figure 2 in the following case study). This matrix approach provides a vehicle for evaluating the range of management alternatives against a set of selection criteria. The suggested criteria cover a variety of issues related to the implementation of any management program. A given management option may seem quite desirable according to some of the criteria but less desirable from the perspective of other criteria. A strategy with high odds of producing the desired outcome may be impractical due to the difficulty or cost of implementation, or it may be inadvisable if it causes as many problems in terms of visitor acceptance or other experience indicators as it solves for the original problem condition. There are generally no single right or wrong answers for dealing with visitor impacts. It seems most reasonable to strive for a balance among criteria when selecting a particular management technique.

Step 8: Implementation.--The selected management strategies should be implemented as soon as the necessary resources are available. Because the nature and causes of visitor impacts are highly variable, management programs designed to deal with these impacts should be flexible and quick to respond to changing conditions.

The task of managing visitor impacts is not over when a management program has been implemented. Monitoring of key impact indicators and use patterns is critically important to determine whether the management actions are producing the desired outcomes without altering other characteristics of the experience. Monitoring for future iterations of the process is the final component regardless of the outcome of any particular step in the process. Thus, the process is a continuous framework for evaluation of visitor impacts that builds a data base as it responds to conditions at various points in time.

CASE STUDY: ICEWATER SPRING SHELTER

Description and Problem Statement

Icewater Spring Shelter is one of 18 trail shelters within Great Smoky Mountains National Park. Like most of the shelters within the park, Icewater Spring is located adjacent to the Appalachian Trail (AT) and provides overnight accommodations to through trail hikers. Its location on Kephart Ridge near Mt. LeConte, Charlie's Bunion and several other popular destinations makes Icewater Spring a common overnight stop for two or three night loop hikes as well as a popular stop for day hikers. Use of the Icewater Spring Shelter is limited by bunk space to 12 people per night and regulated through a reservation/permit system operated by the park. Because of its location and attractiveness to various types of visitors, Icewater Spring is the most heavily used backcountry shelter within the park.

Park management has expressed concern about deteriorating resource quality, sanitation and the quality of the visitor experience at the site. Yet existing park information systems, including annual backcountry campsite impact assessment records, have not been used to evaluate the situation at Icewater Spring. In essence, Icewater Spring represents an overnight backcountry destination with perceived impact "problems" in spite of an existing numerical capacity limitation and a relatively complete information system. Consequently, the site provides an opportunity to test the applicability of the VIM framework: (1) as a means of documenting whether or not a problem condition exists; (2) as a vehicle to guide the use of existing information; and (3) as a framework for the evaluation and management of localized visitor use patterns.

Implementing the Process

Step 1.--The preassessment data base review involved collecting and reviewing a variety of types of data from park records and personnel. Park planning documents were reviewed for pertinent guidelines and constraints to management. Such documents also provided overviews of major resources and visitor use patterns and trends. Obtaining detailed, site-specific information, however, required going to original sources such as backcountry use files. The preassessment data base review resulted in the following background information:

-Icewater Spring has the highest use rate of all shelters in the park (approximately 10 percent of all shelter use).

-Twenty-five percent of Icewater Spring's overnight use between April 1 and June 15 is reserved for through hikers on the AT.

-Most AT through hikers stop at Icewater Spring.

-Use Statistics for Icewater Springs:

	No. of Camper Nights	% of Total Shelter Use	% of Total Backcountry Use
1984	2471	9.9	--
1983	2531	9.2	3.6
1982	2810	9.6	3.8
1981	3122	10.0	3.8
1980	3107	9.7	3.6

-According to interagency agreements, location of the shelter on the Appalachian Trail requires maintaining access for through hikers, thereby removing the option of closing the site.

-The general priorities for backcountry human waste disposal, as stated in the Park's General Management Plan are: (1) temporary closure, (2) permanent closure, and (3) installation of toilet system. The plan further states that pit toilets will be allowed at AT shelters where closing is not practical and soil profiles are favorable.

Step 2.--The second step in the process involved examining park planning documents to identify the existing management objectives applicable to the situation. It seemed reasonable to begin by trying to interpret the general goals and objectives reflected in various park documents and to then look for increasingly specific policy statements. One could not expect to find a list of objectives for the Icewater Spring Shelter in existing planning documents. The challenge of this step was to interpret and extract the wide range of objectives that have a bearing on the shelter use situation.

The objectives identified tended to center on relatively general statements to the effect that visitor activities would be promoted at appropriate locations, levels and times so as to minimize impacts on park resources and the quality of the visitor experience. The most applicable objectives from the backcountry management plan stated that human and horse waste, garbage and trash would not be allowed to reach obtrusive levels, nor to cause fecal contamination of water resources or threaten the health of backcountry users.

Step 3.--The selection of key impact indicators required the identification of variables to be used in measuring whether or not the relevant management objectives are being met. This step in essence involves listing measurable environmental and experiential variables that are most pertinent to the management objectives. In this case, a set of variables included on the park's backcountry campsite impact evaluation form provided potential indicators corresponding primarily to environmental quality objectives. The advantage of using these indicators is that a corresponding data base exists as a result of annual observations of these

variables at all designated backcountry sites. The limitation of these indicators is that they do not represent all of the management objectives pertinent to the situation.

The following list of recommended indicators includes some variables from the existing impact evaluation instrument and some additional indicators based on the potential problems and objectives identified earlier:

Indicator	Issue/Objective
Overall site impact	Resource Protection
Human waste	Sanitation/Aesthetics
Vegetation damage	Resource Protection
Amount of trash	Aesthetics/Sanitation
Number of pest complaints	Sanitation/Aesthetics
Number of crowding complaints	Quality of Visitor Experience

Step 4.--While no specific standards already existed for the indicators selected at Icewater Spring, some approximation of current standards could be interpreted from the material collected previously. Quantitative standards for the overall impact score and the human waste and vegetation damage indicators were estimated through discussions with park personnel on the interpretation of scores from the campsite impact assessment instrument. The existing backcountry impact assessment system involves numerical ratings for six impact indicators. Each indicator is rated in relation to a maximum number of points representing ideal conditions (bare soil-35 points; firewood-10 points; bear incidents-15 points; human waste-15 points; horse waste-10 points; damage to vegetation-15 points). A campsite with no evident impacts could thus receive a maximum overall impact score of 100 points. In assessing backcountry site impacts, points are subtracted from the maximum possible scores in proportion to the extent to which each indicator is present. Ratings for the bare soil, firewood, and bear incident indicators are based on quantitative measurements; scores for the remaining indicators reflect subjective evaluations of the extent of impact where the total possible points are subtracted for "severe" or "excessive" impacts, 5 points are deducted for "some" or "moderate" impacts, and no points are lost if the indicator is "not evident or small amount."

Standards were determined only for those indicators selected in step 3. Standards for the three indicators from the existing impact evaluation form suggested that acceptable sites would score above 70 for the overall impact rating and would receive at least 10 points (i.e., no more than 5 points subtracted) for the human waste and vegetation damage indicators. For the remaining indicators, no quantitative standards were available but qualitative standards were apparent from relevant management objectives. One alternative open to managers at this point is the selection of more specific quantitative standards to replace the more qualitative standards that typically exist. For purposes of this case study, the mixture of qualitative and quantitative standards was retained in order to test the relative usefulness of both types of standards.

Step 5.--The next step in the process calls for comparing the standards selected with the actual conditions found at the site. Data were collected for this comparison from existing backcountry impact assessment records and field visits to Icewater Spring. The existing backcountry impact data revealed that conditions at Icewater Spring have been relatively consistent for the previous five years. The overall impact rating has remained between 80 and 83 on a 100 point scale, while human waste and damage to vegetation received scores ranging from 5 to 15 on a scale where 15 represented no impact:

Indicator	1984	1983	1982	1981	1980	Mean
Overall Site Impact (100 pts)	83	82	82	80	80	81
Human Waste (15 pts)	10	5	6	10	5	7
Vegetation Damage (15 pts)	10	13	13	10	15	12

Comparing this data with the corresponding standards shows that the overall site impact and vegetation damage were within acceptable levels, while the level of human waste was not consistent with the standards. In addition, field observations for two of the new indicators not included on the existing impact rating instrument (trash and pest complaints) showed that conditions for these indicators were not acceptable according to the corresponding qualitative standards. These results suggest that the most significant problems at Icewater Spring are unacceptable levels of human waste and trash along with complaints about the presence of the types of pests (skunks, rats, etc.) associated with these conditions.

Indicator	Current Conditions	Standard
Overall site Impacts	80-83 points	70 points
Human waste	5-10 points	10 points
Vegetation damage	10-15 points	10 points
Amount of trash	moderate	unobtrusive
No. of pest complaints	occasional	none
No. of crowding complaints	infrequent	infrequent

Step 6.--With unacceptable impacts identified, the next step involved searching for the most important probable causes of the specific impact conditions. The causal factors may include various aspects of site use patterns as well as some physical features of the site. Research

would be helpful at this point to demonstrate relationships between impact indicators and potential causal factors. An interim evaluation of probable causes, using the best available data coupled with informed opinion and knowledge of the area, revealed that all impact indicators are not affected the same way by all causal factors. Human waste, for example, may be more directly attributable to the total number of users while trash and pest incidents are more strongly related to inappropriate visitor behavior.

Step 7.--The final step in the process involved reviewing a range of management alternatives for dealing with the unacceptable impact conditions. In light of the many factors that may be contributing to the conditions, it is wise to consider a wide range of strategies and to allow for the possibility of using multiple strategies in combination. The process of completing a matrix in which various strategies are evaluated against a set of criteria can help to identify the advantages, disadvantages and trade-offs between alternatives (figure 2). The management actions included in the matrix represent a broad spectrum of direct and indirect strategies. The evaluation criteria listed reflect some of the issues that may affect the implementation of a given strategy in addition to the potential effectiveness for controlling the major unacceptable impacts identified earlier. Judgments for each of the cells within the matrix are best estimates based on all of the information collected previously.

Results shown in figure 2 suggest that there is no panacea for reducing visitor impacts at Icewater Spring and there are trade-offs between alternatives. Some strategies that are perhaps the most likely to eliminate problem conditions (e.g., permanent or temporary closure) may be unacceptable from the standpoint of visitor resistance or inconsistency with management objectives. Reducing overnight capacity may ameliorate conditions at peak use times but probably will not completely eliminate the unacceptable impacts. Facility-oriented solutions like pit toilets will address one aspect of the situation but may lead to other problems like vandalism. In addition, their effectiveness may be limited if campers and hikers dump trash in the toilets, as has happened elsewhere.

	MANAGEMENT STRATEGY						
CRITERIA FOR EVALUATION	Pit or Compost Toilet	Increased Maintenance Patrols	Minimum Impact Education	Recommend Alternate Sites	Reduce Capacity	Temporary Closure	Permanent Closure
Consistency with Management Objectives	high	high	high	high	moderate to high	moderate	low
Cost of Implementation	moderate	high	low	low	low	moderate	high
Factors Limiting Application	mainte-nance; soil suitability; vandalism	available personnel	receptivity of visitors	number of visitors seeking advice	communi-cation & enforce-ment	communi-cation & enforcement	communi-cation & enforcement
Potential Visitor Resistance	low	low	low	low	moderate	moderate to high	high
Potential effectiveness for controlling human waste	high	low	moderate	low to moderate	moderate	high	high
Potential effectiveness for controlling trash/ litter	low	high	moderate	low to moderate	moderate	high	high
Potential effectiveness for controlling pest incidents	low	high	moderate	low to moderate	moderate	high	high

Figure 2.--Matrix for evaluation of management alternatives at Icewater Spring Shelter.

Clearly, a range of reasonable options are available to the manager. Various strategies may be phased in as money and manpower resources allow. Whatever strategies are selected, it will be important to continue monitoring of the site and the probable causal factors to determine whether or not the management activities are bringing conditions back to the standards for the area.

This case study was initiated during a field visit to Great Smoky Mountains National Park during summer, 1985, and was conducted with the cooperation and assistance of the park's staff. While the results reported here were completed during the field visit to the park, the selection of a management strategy and subsequent implementation remained in the hands of park management. Additional time will be needed to assess whether use of the process can lead to improvements in site conditions at Icewater Spring.

CONCLUSIONS

This paper has demonstrated the application of the visitor impact management framework on a site-specific basis. The Icewater Spring case study followed a series of logical steps, using the best available data, to document the nature and extent of visitor impacts at the site. The results included documentation of unacceptable conditions as well as a means of evaluating the appropriateness and trade-offs between a wide range of management alternatives. The case study also identified where further information can help to support management decisions. If managers are uncomfortable with the level of subjectivity in available impact measures, they may pursue more precise or less subjective measures. Similarly, managers may invest some effort in writing more specific objectives and translating them into more quantitative standards. It makes little sense to invest heavily in precise impact assessment if the standards for comparison are not stated in units comparable to site measurements.

Such additional efforts are not necessary, however, to achieve useful outcomes from the VIM process. The case study illustrated that the various steps within the process can be implemented using varying levels of data and quantification. A major premise of the VIM framework is that the use of a systematic, logical process that incorporates the best available information and scientific understanding will lead to informed and defensible management decisions.

The Icewater Spring case study was one of a series of pilot test efforts examining the applicability of the VIM framework in different types of situations. Other case studies focus on the application to planning for larger areas incorporating a number of sites, and the use of VIM to assess front country impact problems (Graefe and others 1986). In addressing these diverse types of challenges, the visitor impact management framework attempts to integrate and build upon other management and planning processes designed for particular applications (e.g., Shelby and Heberlein 1984; Stankey and others 1985).

The recent literature includes a promising assortment of approaches and tools for the various problems facing natural resource managers. Visitor impact management is one such strategy, which may be used alone or in combination with another planning framework, to approach the difficult task of managing recreational impacts in natural areas.

REFERENCES

Brown, P. J. Information needs for river recreation planning and management. In: River Recreation Management and Research: Proceedings; 1977 January 24-27; Minneapolis, MN. General Technical Report NC-28. St. Paul, MN: U. S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 193-201.

Drogin, E. B.; Graefe, A. R.; Vaske, J. J.; Kuss, F. R. Recreation impacts and carrying capacity: a bibliography and literature analysis. Washington, D.C.: National Parks and Conservation Association; 1986. 341 p.

Graefe, A. R.; Vaske, J. J.; Kuss, F. R. Social carrying capacity: an integration and synthesis of twenty years of research. Leisure Sciences. 6(4):395-431; 1984.

Graefe, A. R.; Kuss, F. R.; Vaske, J. J. Recreation impacts and carrying capacity: a visitor impact management framework. Washington, D.C.: National Parks and Conversation Association; 1986. 82 p.

Hendee, J. C.; Stankey, G. H.; Lucas, R. C. Wilderness management. Miscellaneous Publication No. 1365. Washington, D.C.: U. S. Department of Agriculture, Forest Service; 1978. 381 p.

Kuss, F. R.; Graefe, A. R.; Vaske, J. J. Recreation impacts and carrying capacity: a synthesis of ecological and social research. Washington, D.C.: National Parks and Conservation Association; 1986. 181 p.

Shelby, B.; Heberlein, T. A. A conceptual framework for carrying capacity determination. Leisure Sciences. 6(4):433-452; 1984.

Stankey, G. H. Wilderness carrying capacity: management and research progress in the United States. Landscape Research. 5(3):6-11; 1980.

Stankey, G. H.; Cole, D. N.; Lucas, R. C.; Petersen, M. E.; Frissell, S. S. The limits of acceptable change (LAC) system for wilderness planning. General Technical Report INT-176. Ogden, UT: U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

Washburne, R. F. Wilderness recreational carrying capacity: are numbers necessary? Journal of Forestry. 80(1):726-728; 1982.

DENSITY AND CROWDING IN WILDERNESS:

SEARCH AND RESEARCH FOR SATISFACTION

Robert E. Manning

ABSTRACT: The last two decades have generated a large number of conceptual and empirical studies examining crowding and its relationship to visitor satisfaction in wilderness and related environments. This paper reviews and synthesizes this literature and develops a model illustrating a state-of-the-art knowledge of crowding in outdoor recreation. The model begins by recognizing that increasing density of recreation use causes increasing contacts between recreation parties, but other variables mediate this effect, including the inherent spatial and temporal complexities of trip patterns. Second, the model illustrates that contacts between parties affect perceived crowding, but so do the ways in which these contacts are interpreted. Crowding norms based on personal characteristics of visitors, characteristics of those encountered, and situational variables affect the point at which contacts are evaluated negatively. Third, perceived crowding affects overall satisfaction, but is only one of theoretically many variables to do so. Last, perceived crowding can result in displacement of some users so their satisfaction is not measured by on-site studies.

INTRODUCTION

This paper examines a large and growing genre of research on crowding in outdoor recreation. There is a relatively long history of concern over the effects of increasing use on the quality of the recreation experience, particularly in wilderness and related environments. Wagar's (1964) conceptual application of carrying capacity to outdoor recreation, and particularly the development of a social carrying capacity component, marks the beginning of serious social scientific study of crowding in outdoor recreation.

The two decades since passage of the Wilderness Act have generated a large number of theoretical and empirical studies examining crowding in outdoor recreation and its relationship to visitor satisfaction. These studies have emanated from a variety of academic disciplines including geography, economics, sociology, and psychology. Findings from these studies indicate that crowding is a complex issue: some studies have found an inverse relationship between density/crowding and satisfaction while many have not. The purpose of this paper is to review and synthesize this literature and present a state-of-the-art knowledge of crowding in wilderness and related outdoor recreation environments. The literature is divided and discussed in three broad categories: a normative approach to crowding, coping behavior, and methodological issues. This is followed by presentation of a model of crowding and development of management and research implications.

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A NORMATIVE APPROACH TO CROWDING

A large number of studies have supported the notion that crowding is a normative concept. That is, increasing use density is not negatively interpreted as crowding until it is perceived to interfere with or disrupt one's objectives or values. This approach has proved fertile for theory building and testing. A variety of factors have been suggested as forming the basis for crowding norms, among them the personal characteristics of visitors, characteristics of others encountered, and situational variables.

Personal Characteristics of Visitors

Personal characteristics of visitors found to influence crowding norms are motivations for outdoor recreation, preferences and expectations for contacts, experience level, and attitudes toward management.

Motivations, preferences and expectations.—The three interrelated factors of motivations for recreation, and preferences and expectations for contact have been included in several crowding studies. The most comprehensive study (Ditton and others 1983) included all three factors in a survey of visitors to the Buffalo National River, Arkansas. Wide diversity in perceived crowding was found among the sample of river floaters and motivations for the trip were found to be significantly related to perceptions of crowding. Not surprisingly, respondents who felt crowded reported significantly higher ratings on the motivation "to get away from

other people", while those whose enjoyment was enhanced by contacts reported significantly higher ratings on the motivations "to be a part of a group," "to have thrills and excitement," and "to share what I have learned with others." In addition, floaters who felt crowded reported lower fulfillment ratings for seven of the nine motivations tested. The survey also included questions on expected and preferred number of contacts. Mean scores comparing reported with expected contacts were consistently found to be significantly higher for respondents who felt crowded than for groups reporting neutral effect or increased enjoyment. Those who felt crowded were more likely to report having seen more people than expected. The same results were obtained for preferred contacts: those who felt crowded were distinguished from others by the fact that they tended to report experiencing more contacts than they preferred. These results have been corroborated by all other studies addressing these factors.

Experience.—Perhaps the most widely studied personal characteristic thought to affect crowding norms is experience. Experience level is thought to affect normative definitions of crowding either through refinement of tastes or by virtue of exposure to lower density conditions as a result of earlier participation. The bulk of the empirical evidence supports the notion that more experienced users are more sensitive to higher densities. This appears true regardless of how experience is measured: general experience in the activity, rate of participation, experience on-site, or some other dimension. Vaske and others (1980), for example, found a positive relationship between on-site experience and sensitivity to crowding among visitors to Apostle Islands National Lakeshore, Wisconsin. And the study by Ditton and others (1983) described above found similar relationships across several measures of experience.

Attitudes.—Finally, attitudes of visitors have been found to affect crowding norms, particularly the extent to which attitudes conform with values suggested in the Wilderness Act ("wilderness purism"). Both studies which have applied a wilderness purism scale to the issue of crowding have found that it distinguishes among respondents with respect to perceptions of crowding. Satisfaction curves (relating satisfaction to hypothetical encounter levels) derived by Stankey (1973) from wilderness users were found to be distinctly different for strong purists and average visitors. For strong purists, satisfaction declined both more quickly and more steeply. And under field conditions, Schreyer and Roggenbuck's (1978) study of floaters on the Green and Yampa Rivers found that those with the most purist attitudes consistently registered a higher degree of perceived crowding at each encounter level.

Characteristics of Those Encountered

There is considerable evidence that the characteristics of those encountered also affect crowding norms. Factors found important include type and size of group, behavior, and perceptions of alikeness.

Type and size of group.—Studies of conflict between types of groups in the outdoors are legion. It seems only reasonable to think that tolerance for meeting another group would depend, at least to some extent, on its characteristics. Several studies support this view empirically, with the type of group most often defined in terms of mode of travel. Lucas's (1964) early study in the Boundary Waters Canoe Area, for example, found that paddling canoeists distinguished sharply among the three types of area users when asked their reactions to meeting other groups. They disliked encountering motorboats, were less resentful of encountering motorized canoes, and enjoyed encountering at least some other paddled canoes. Motor canoeists made similar distinctions, though not as sharply. Thus, canoeists felt crowded at much lower levels of use where motor boats were present.

Considerable support has also been found that party size affects crowding judgments. For example, Stankey (1973) found that the majority of wilderness visitors would rather encounter ten small parties per day than one large party.

Behavior.—The behavior of other groups also seems to affect crowding norms. Driver and Bassett (1975) found that about half of fishermen and streamside residents on the Au Sable River, Michigan, objected to seeing canoeists; however, they objected primarily because of inconsiderate behavior, such as yelling or shouting, rather than sheer numbers. West (1982) conducted a more detailed study of behavior and its relationship to perceived crowding. His study of national forest hikers found that 30.9 percent were bothered by other users. Probing more deeply, it was found that of this total, 56.9 percent were bothered by the behavior of others, 31.4 percent by the number of others encountered, and 4.1 percent by different types of users. Specific forms of behavior reported as bothering respondents were, in decreasing order: noise, yelling, and loud behavior; littering and polluting lakes; and noncompliance with rules. Respondents exposed to high perceived density (those reporting ten or more contacts) and negative behavior felt crowded 47.9 percent of the time, while respondents exposed to high perceived density but not negative behavior felt crowded only 16.7 percent of the time.

Perception of alikeness.—The third characteristic of other groups that seems to affect crowding norms is the degree to which groups are perceived as being alike. This factor appears closely related to behavior, but is more difficult to measure and study. Consequently it

has been addressed more often on a theoretical basis than in the field.

Several recreation researchers (e.g. Cheek 1971; Cheek and Burch 1976; Cheek and others 1976) have noted that the vast majority of people participate in outdoor recreation in family and/or friendship groups. This suggests the notion of solitude so often associated with certain types of outdoor recreation may not mean simple isolation from others. It also suggests an inward focus on interpersonal relationships within the social group. Both of these notions are ultimately important in the concept of alikeness.

Lee (1975, 1977) has done much to further the notion of alikeness among recreation groups. A study of backpackers in Yosemite National Park found no relationship between perceived crowding and behavioral measures of satisfaction. Lee attributes this finding to the idea that most social interaction between groups in outdoor recreation settings is conducted with little conscious deliberation. People are therefore largely unaware of such social interaction, and it has little effect on perceptions of crowding. Lee concludes that the quality of a recreational experience "appears to be closely linked with the opportunity to take for granted the behavior of other visitors," and that "an essential ingredient for such an experience (is) the assumption that other visitors are very much like oneself, and will, therefore, behave in a similar manner." Thus, to the extent that groups are perceived as alike and require little conscious attention, encounters have limited disruptive effects.

Situational Variables

The environment in which encounters occur apparently dictates, to some extent, the way in which these encounters are perceived and evaluated. Important variables include the type of recreation area, location within an area, and environmental design and quality.

Type of area.—Clawson and Knetsch (1966) suggested very early that there are inter-area differences in crowding norms. Hypothetical curves relating the effects of density to recreation quality were seen as taking dramatically different shapes for three types of recreation areas: wilderness, an unimproved campground, and a highly developed campground. That different use levels are appropriate for different types of recreation areas seems obvious in a conceptual way, though not much is known about the issue in a quantitative sense. Empirical evidence is offered by McConnell's (1977) study of density and crowding (measured as willingness to pay) which found different relationships at different types of beaches ranging from a natural area to a highly developed "singles" beach. Manning and Ciali (1981) also found different patterns of desired use density among users of six river types.

Location within an area.—More focus has been placed on intra-area differences in crowding norms. The most consistent finding has been high sensitivity to encounters associated with campsite location. Burch and Wenger (1967), for example, found that two-thirds of wilderness visitors preferred a campsite far away from others. Stankey (1973, 1980) also found wilderness visitors sensitive to campsite encounters. The vast majority of respondents (75 percent) agreed with the statement, "When staying out overnight in the wilderness, it is most enjoyable not to be near anyone else." Visitors also reported higher sensitivity to encounters at campsites than along trails. Lucas (1980) reports similar findings: the large majority of visitors to nine wilderness areas preferred to camp alone.

Heightened sensitivity to encounters has also been found in the interior of wilderness as opposed to the periphery (Stankey 1973). Given the choice, 68 percent of wilderness visitors expressed a preference for encounters to occur within the first few miles from the road rather than interior zones.

Environmental factors.—Hammitt (1983) has suggested that crowding may also depend on the physical, non-human environment. An office, for example, can be perceived as crowded because the amount and configuration of furnishings prohibit one from functioning as desired, even when no one else is present. This issue has received little research attention, though Womble and Studebaker's (1981) study of crowding in a national park campground is suggestive. This study found very little relationship between density and perceived crowding. However, the authors went on to explore the open-ended comments section of the questionnaire in an effort to identify other factors which might account for unexplained variance in crowding perceptions. Several factors were identified, the most important of which were proximity of campsites and insufficient facilities. This suggests design aspects of the recreation environment may be involved in normative definitions of crowding.

A related consideration is the perceived quality of the recreation environment. Vaske and others (1982) created an index of perceived environmental disturbance for visitors to the Dolly Sods Wilderness, West Virginia. The index indicated that visitors generally found environmental conditions about the same or slightly better than expected. However some respondents rated conditions worse than expected, and this had a substantive effect on perceived crowding. When the perceived environmental disturbance index was added to measures of reported, preferred, and expected contacts, the amount of variance explained in perceived crowding rose from 23 percent to 33 percent. Moreover, the index had the largest effect on perceived crowding of any of the four independent variables. These findings indicate that perceived crowding is influenced not only by the physical

presence of others, but also by the environmental impacts left by previous visitors. These findings are consistent with other studies which indicate that visitors are often more disturbed by the presence of litter or other environmental degradation than by contacts with other parties (Lee 1975; Lucas 1980; Stankey 1973).

COPING BEHAVIOR

Crowding research has also focused on potential coping behaviors of recreationists. It has been suggested that when the environment becomes too densely populated, new behaviors are adopted which help relieve associated stress and anxiety. It has been widely hypothesized that outdoor recreationists utilize two forms of coping behavior: displacement and rationalization.

Displacement

Many writers have suggested that as use densities increase some recreationists become dissatisfied and alter their patterns of recreation activity to avoid crowding, ultimately moving on to less densely used areas. In this manner, they are displaced by users more tolerant of higher densities.

A number of studies have addressed this hypothesis empirically. Several have focused on changes in behavior as related to density concerns. Rafters on the Colorado River in Grand Canyon National Park, for instance, changed their trip plan as a function of the density of river use (Neilson and Shelby 1977). Changes included limiting the number of attraction sites visited and the time spent at each, both actions designed to limit contact with other rafting parties.

A slightly different methodology was applied in a study of visitors to the Boundary Waters Canoe Area, and indications of displacement were again found (Anderson 1980; Anderson and Brown 1984). Visitors who had made more than four trips to the area were studied to determine changes in trip patterns over time. The vast majority of respondents were found to have changed their pattern of use by selecting different entry points or campsites, or entering on a different day of the week. Factors related to trip changes included use density, litter, noise, and environmental impacts.

A final group of studies has examined shifts in recreation sites. One study, for example, analyzed use of two rivers in the same geographic area (Becker 1981; Becker and others 1981). A group of users was identified who had purposely shifted use from one river to the other, at least partially in response to density conditions. These findings support the displacement hypothesis. Another study, however, found no support for this hypothesis. An on-site survey of national forest visitors in Michigan, coupled with a telephone survey of past visitors, found that past visitors who no longer used the area did not have greater perceptions of crowding than other categories of visitors (West 1981a). Nor was there any relationship between feeling crowded and intent to visit the area again.

Thus, evidence concerning the displacement hypothesis is not definitive. The ideal research approach--a longitudinal or panel study--has not yet been applied to this issue. However, the bulk of existing evidence is suggestive of changing trip patterns and, to some extent, shifts in areas used due to increasing use levels and associated effects.

Rationalization

Rationalization is a second coping behavior hypothesized in outdoor recreation (Heberlein and Shelby 1977). Some people may rationalize and believe that they had a good time regardless of conditions, since recreation activities are voluntarily selected and sometimes involve a substantial investment of time, money, and effort. This hypothesis is rooted in the theory of cognitive dissonance, and suggests that people tend to order their thoughts in ways that reduce inconsistencies and associated stress. Therefore, people may be inclined to rate their recreation experience high regardless of actual conditions to reduce internal conflict.

This hypothesis appears reasonable when applied, as it originally was, to Colorado River/Grand Canyon users. For most people, this trip is a substantial undertaking: trips are long, normally requiring at least a week; commercial passengers pay high fees; and private trips may have to wait a year or considerably longer to receive a permit. Under these conditions, many people might refuse to be easily disappointed. The hypothesis loses some of its appeal, however, when applied to less extraordinary circumstances. Little support for this hypothesis, for example, was found in a study of river use in Vermont (Manning and Ciali 1980). Most visitors were in-state day users. With such a relatively small investment in their trip, it seems likely they would have admitted they had had an unsatisfactory experience because of crowding or for any other reason. Indeed, many respondents were not hesitant to express dissatisfaction, with reported satisfaction ratings ranging throughout the response scale. Thus, rationalization may apply only to more extraordinary recreation sites and activities.

METHODOLOGICAL ISSUES

Investigations of the relationships between density, crowding and satisfaction have brought to light several important methodological issues which potentially affect these relationships. These include the distinction between use

density and contacts, alternative measures of contacts, the multidimensional nature of satisfaction, and the need for behavioral measures of crowding and satisfaction.

Density and Contacts

It is often implicitly assumed that increased density results in proportional increases in contacts. But the limited research into this issue indicates otherwise. Density of floaters on the Colorado River in Grand Canyon (defined as the number of people per week leaving the principal put-in point) was measured simultaneously with contact levels between parties (Neilson and Shelby 1977; Neilson and others 1977; Shelby 1980). The variables were positively related to a high degree, but density explained only about half the variation in contact levels. Bultena and others (1981) report an even lower relationship between density and contacts in the backcountry of Mount McKinley National Park. The unexplained variance in contact levels may be due to the complexity and randomness of trip patterns, intervening structural elements of topography and geography which limit contacts, purposive behavior to avoid contacts as use levels increase, and other unknown factors. These findings suggest the need for a research and management emphasis on measuring contacts in addition to density. While density measures are more readily available, it is contacts with other parties that visitors experience and which are likely to affect perceived crowding and satisfaction.

Measuring Contacts

A related issue concerns how contacts are measured. Three techniques are found in the literature: actual contacts--recorded by a participant observer (Shelby 1980); reported contacts--self-reports by respondents after the outing (e.g. Manning and Ciali (1980)); and diary contacts--self-reports by respondents recorded during the outing (McCool and others 1977). Shelby and Colvin (1982) have compared the three measures using samples of river floaters on the Rogue and the Illinois Rivers, Oregon. Users who experienced fewer than six contacts were generally accurate (by comparison with actual contacts) in reporting them, but at higher levels of contact most users reported only about half as many contacts as actually occurred. Reported and diary contacts were found to be in close agreement. Thus, in low density recreation areas, self-reported contacts can probably be relied upon as reasonably accurate and should generally be used due to the administrative difficulties and potential intrusion on the visitors' experience represented by diaries. But in relatively high density areas, reported and diary contacts must be used with caution. Unfortunately, actual contacts are usually difficult and expensive to measure. However, the potential usefulness of reported and diary contacts by managers and researchers should not be overlooked, even when they are known to be inaccurate. Self-reports represent the visitors' perceived reality and this can be important in assessing recreation quality.

Multidimensional Nature of Satisfaction

Perhaps the most important methodological issue concerning the relationships discussed in this paper is measurement of satisfaction. Satisfaction is not simply a function of density or crowding, but is a multidimensional concept. This is illustrated in the studies of Lee (1975) and Shelby (1980) discussed earlier. In these studies, feelings of being crowded had little or no effect on satisfaction. Both studies go on to identify a number of diverse variables which are correlated with satisfaction, including absence of litter and other pollution, low level of facility development, pleasant social demeanor of others, and good physical condition of the trail.

The problem of measuring satisfaction as a function of density or perceived crowding has been illustrated by Manning and Ciali (1980). In this study the relationship between density and satisfaction was measured under both actual field conditions and a hypothetical convention whereby respondents are implicitly asked to assume away all other factors and to focus only on the two variables under consideration. Using the latter method, a clear negative relationship was found. But caution should be used in interpreting such findings and incorporating them into management policy. Research results from this idealized and rigorous world of fixed external variables may not hold under more complex field conditions. Tested under actual field conditions, no relationship was found between density and satisfaction; but once again, caution must be used in interpreting these results. The absence of relationships may be due to masking by more powerful but unknown variables, such as weather conditions.

The potentially complex effects of density on satisfaction have also been illustrated in a study of deer hunting (Heberlein and others 1982). Density of hunters was found to have both positive and negative effects on overall satisfaction. Increased hunter density results in more deer seen per hunter (as more deer are moved through the area) and this has a positive effect on satisfaction. However, increased hunter density also results in more interference among hunters and this detracts from satisfaction.

Ditton and others (1981) suggest that a multiple-item approach to measuring satisfaction may help resolve this dilemma, and developed and tested a five-item satisfaction scale in their study of floaters on the Buffalo National River, Arkansas. Results indicated that a better model of overall satisfaction could be obtained with the multiple-item scale than with any of the

individual scale items. Moreover, different independent variables entered the regression models for each of the individual satisfaction scale items, indicating that each item was tapping a somewhat different dimension of satisfaction. Shelby and others (1980) endorse the notion that single, global measures of satisfaction are generally inadequate. In most cases researchers and managers are interested in evaluating the effects on users of a single attribute such as contact level, and global measures of satisfaction are generally too far removed from single attributes to be effective evaluation measures. Empirical findings tend to support this notion. A detailed study of satisfaction among campers measured satisfaction for individual attributes of the camping experience in addition to overall satisfaction (Dorfman 1979). Though overall satisfaction was correlated with other measures of satisfaction to a statistically significant degree (R generally ranged between .30 and .60), it is clear these variables were not measuring the identical concept.

The Need for Behavioral Measures

A final methodological issue concerns the need for behavioral measures of crowding and satisfaction or, more precisely, multiple measurement approaches. Research in outdoor recreation has been dominated by survey methods. A review of methodological approaches employed in studies published in the Journal of Leisure Research, for example, found that 94 percent used survey techniques (Riddick and others 1984). While survey methods can be exceedingly useful, their potential shortcomings are well documented particularly the potential weakness of the assumption that attitudes are closely related to behavior. Two studies on the crowding issue point out this potential weakness. Lee (1977) found that even though many respondents reported feeling crowded, observations of their behavior indicated little or no effort to achieve additional privacy. This result obviously calls into question the validity of self-reports on crowding in this case (and perhaps others as well). West (1981b) also raises questions about self-reports or surveys of crowding perceptions. His survey of national forest backpackers found 22 percent reporting feelings of crowding, but 70 percent of this subsample was not in favor of lowering permitted use levels.

These findings suggest a more diversified research approach in outdoor recreation. While behavioral measures of outdoor recreation through techniques such as observation also have potential weaknesses, these are different from those of the survey approach. The best solution is therefore to apply both research approaches, using each to validate the other.

A CROWDING MODEL

The issues discussed in this paper are incorporated in the model of crowding shown in figure 1. The model recognizes that density of recreation use (box 1) results in contacts between parties (box 2), but that other variables affect contacts as well, including topography, geography, and the complexities of trip patterns (box 3). Moreover, the way in which contacts are measured will affect the ultimate number derived (box 4). Second, the model shows that contacts between parties affect perceived crowding (box 5), but so do the way in which these contacts are interpreted (box 6). Crowding norms based on personal characteristics of visitors, the characteristics of those encountered, and situational variables affect the point at which contacts are evaluated negatively. Third, perceived crowding affects overall satisfaction (box 7), but is only one of theoretically many variables to do so (box 8). Moreover, the relationship between perceived crowding and satisfaction depends on measurement techniques (box 9). And feelings of perceived crowding can result in displacement of some users (box 10) so their satisfaction ratings are not measured.

MANAGEMENT AND RESEARCH IMPLICATIONS

Current understanding of crowding in wilderness and related environments suggests a number of research and management implications.

1. As the normative approach to crowding inherently suggests, there is considerable diversity among visitors about appropriate contact levels.
2. Based on this diversity among visitors, a variety of contact opportunities should be provided.
3. Recreation areas and zones should be established and managed to encourage relatively homogeneous groups in terms of party type and size, behavior, and other factors which contribute to perceptions of alikeness.
4. More research is needed into what constitutes perceptions of alikeness between recreation parties. Inherent in this issue is why visitors often don't report all of the actual contacts they experience.
5. Determining appropriate contact levels for a recreation opportunity is ultimately a value judgment which must be made by managers.
6. Different contact levels within an area or zone may be appropriate depending upon when and where contacts occur and whom is encountered.
7. Crowding is subject to multiple management approaches including use limitations, spatial and temporal use redistribution, facility design, maintenance of environmental quality, compliance with rules and regulations, and planning for relatively homogeneous groups of visitors.
8. Satisfaction is not a proper criterion for managing crowding in recreation areas. If the process of displacement is operating or if

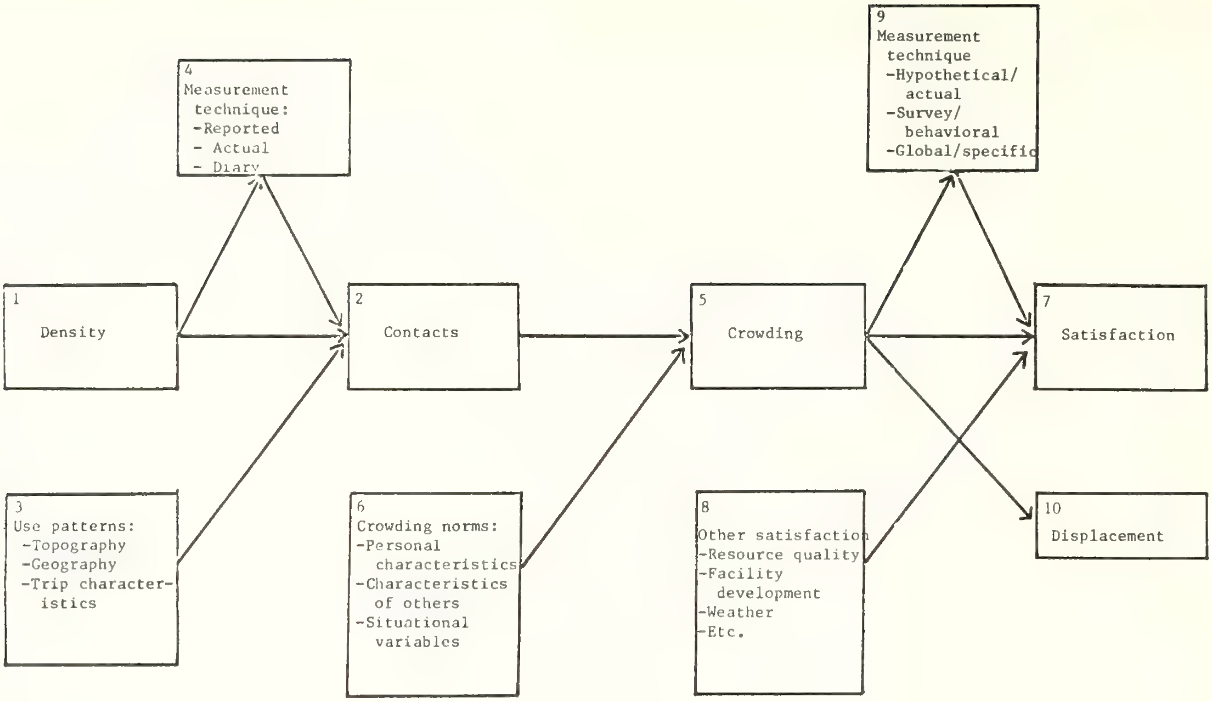

Figure 1.--Crowding model.

in some other way the population of visitors is changing, satisfaction is likely to remain high despite changing density conditions. The ultimate result will be loss of diversity in outdoor recreation opportunities, particularly low-density alternatives.

9. Longitudinal study of the process of displacement is needed to determine the extent to which it operates.

10. Global measures of satisfaction are generally not appropriate for either research or management purposes. More attribute-specific satisfaction measures are needed.

11. Management and research attention should be focused on contact levels in addition to more readily available density or overall use level. Contacts are more directly related to perceptions of crowding than density of use.

12. "Solitude" in wilderness and related outdoor recreation environments has several meanings in addition to the traditional concept of isolation. In particular, opportunities for intimacy within groups are important.

13. Estimates of crowding norms based on survey research might best be interpreted as the lower bounds of contact tolerance. Such estimates might be increased to the extent that groups are compatible.

14. Behavioral measures of crowding and satisfaction should be used to help validate findings from survey research and vice versa.

REFERENCES

Anderson, Dorothy H. Long-time boundary waters' visitors change use patterns. Naturalist. 3(4):2-5; 1980.

Anderson, D.H., and Brown. P.J. The displacement process in recreation. Journal of Leisure Research. 16(1):61-73; 1984.

Becker, R., Niemann, B. and Gates, W. Displacement of users within a river system: social and environmental tradeoffs. In: Some Recent Products of River Recreation Research. General Technical Report NC-63 St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981: 33-38.

Becker, R.H. Displacement of recreational users between the Lower St. Croix and Upper Mississippi Rivers. Journal of Environmental Management. 13(3):259-267; 1981.

Bultena, Gordon; Field, Donald; Womble, Peter; and Albrecht, Don. Closing the gates: a study of backcountry use-limitation at Mount McKinley National Park. Leisure Sciences. 4(3):249-267; 1981.

Burch, William R., Jr.; and Wenger, Wiley D. Jr. The social characteristics of participants in three styles of family camping. Research Paper PNW-48. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1967.

Cheek, N.H. Toward a sociology of not-work. Pacific Sociological Review. 14:245-258; 1971.

Cheek, N.H., Jr., and Burch, W.R. Jr. The social organization of leisure in human society. New York:Harper and Row; 1976.

Cheek, N.H. Jr.; Field, D.R. and Burdge, R.J. Leisure and recreation places. Ann Arbor:Ann Arbor Science; 1976.

Clawson, Marion, and Knetsch, Jack L. Economics of outdoor recreation. Baltimore, Maryland: Johns Hopkins University Press; 1966.

Ditton, Robert B.; Graefe, Alan R. and Fedler, Anthony J. Recreational satisfaction at Buffalo National River: some measurement concerns. In: Some recent products of river recreation research. General Technical Report NC-63. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981: 9-17.

Ditton, Robert B.; Fedler, Anthony J. and Graefe, Alan R. Factors contributing to perceptions of recreational crowding. Leisure Sciences. 5(4):273-288; 1983.

Dorfman, P. Measurement and meaning of recreation satisfaction: a case study of camping. Environment and Behavior. 11(4):483-510; 1979.

Driver, B., and Bassett, J. Defining conflicts among river users: a case study of Michigan's Au Sable River. Naturalist. 26(1):19-23; 1975.

Hammitt, William E. Toward an ecological approach to perceived crowding in outdoor recreation. Leisure Sciences. 5(4):309-320; 1983.

Heberlein, Thomas A.; and Shelby, B. Carrying capacity, values, and the satisfaction model: a reply to Greist. Journal of Leisure Research. 9(2):142-148; 1977.

Heberlein, T.A.; Trent, J.N. and Baumgartner, R.M. The influence of hunter density on firearm deer hunters' satisfaction: a field experiment. In: Transactions of the 47th North American natural resource and wildlife conference; 1982; 665-676.

Lee, R. The management of human components in the Yosemite National Park ecosystem: final research report. Berkeley, California: University of California; 1975.

Lee, Robert G. Alone with others: the paradox of privacy in wilderness. Leisure Sciences. 1(1):3-19; 1977.

Lucas, R. Wilderness perception and use: the example of the Boundary Waters Canoe Area. Natural Resources Journal. 3(3):394-411; 1964.

Lucas, Robert C. Use patterns and visitor characteristics, attitudes, and preferences in nine wilderness and other roadless areas. Research Paper INT-253. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980.

Manning, R. and Ciali, C. Recreation density and user satisfaction: a further exploration of the satisfaction model. Journal of Leisure Research. 12(4):329-345; 1980.

Manning, Robert E., and Ciali, Charles P. Recreation and river type: social-environmental relationships. Environmental Management. 5(2):109-120; 1981.

McConnell, Kenneth E. Congestion and willingness to pay: a study of beach use. Land Economics. 53(May):185-195; 1977.

McCool, Stephen F.; Lime, David W. and Anderson, Dorothy H. Simulation modeling as a tool for managing river recreation. In: Proceedings: river recreation management and research symposium. General Technical Report NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 304-311.

Nielson, Joyce M., and Shelby, Bo. River-running in the Grand Canyon: how much and what kind of use. In: Proceedings: river recreation management and research symposium. General Technical Report NC-28. St Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 168-177.

Nielson, J.; Shelby, B. and Haas, J.E. Sociological carrying capacity and the last settler syndrome. Pacific Sociological Review. 20(4):568-581; 1977.

Riddick, C.C.; DeSchriver, M. and Weissinger, E. A methodological review of research in the Journal of Leisure Research from 1978 to 1982. Journal of Leisure Research. 16(4):311-321; 1984.

Schreyer, R., and Roggenbuck, J. The influence of experience expectations on crowding perceptions and social-psychological carrying capacities. Leisure Sciences. 1(4):373-394; 1978.

Shelby, B. Crowding models for backcountry recreation. Land Economics. 56(1):43-55; 1980.

Shelby, B.; Lowney, D. and McKee, P. Problems with satisfaction as a criterion for management and change. Paper presented at the annual meeting of the Rural Sociological Society, Ithaca, New York; 1980.

Shelby, Bo, and Colvin, Rick. Encounter measures in carrying capacity research: actual, reported and diary contacts. Journal of Leisure Research. 14(4):350-360; 1982.

Stankey, George H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-142. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973.

Stankey, George H. A comparison of carrying capacity perceptions among visitors to two wildernesses. Research Paper INT-242. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980.

Vaske, J.J.; Donnelly, M.P. and Heberlein, T.A. Perceptions of crowding and resource quality by early and more recent visitors. Leisure Sciences. 3:367-381; 1980.

Vaske, J.J.; Graefe, A.R. and Dempster, A. Social and environmental influences on perceived crowding. In: Proceedings of the wilderness psychology group. Morgantown, WV: West Virgina University; 1982:211-227.

Wagar, J. Alan. The carrying capacity of wild lands for recreation. Forest Science Monograph 7. Washington, DC: Society of American Foresters; 1964.

West, Patrick C. On-site social surveys and the determination of social carrying capacity in wildland recreation management. Research Note NC-264. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981a.

West, P.C. Perceived crowding and attitudes toward limiting use in backcountry recreation areas. Leisure Sciences. 4(4):419-426; 1981b.

West, Patrick C. Effects of user behavior on the perception of crowding in backcountry forest recreation. Forest Science. 28(1):95-105; 1982.

Womble, P., and Studebaker, S. Crowding in a national park campground. Environment and Behavior. 13(5):557-573; 1981.

CAMPSITE IMPACT DATA AS A BASIS FOR DETERMINING WILDERNESS USE CAPACITIES

David J. Parsons

ABSTRACT: The dispersal and impact class of over 8,000 backcountry campsites, together with scientific and management judgment on what constitutes acceptable conditions, provided a basis for determining travel zone capacities in Sequoia and Kings Canyon National Parks. The examples presented serve as a model for use capacity determinations in other wilderness areas.

INTRODUCTION

Wilderness managers are faced with the difficult problem of providing for visitors while at the same time assuring that natural conditions and opportunities for solitude are preserved. Concern over the ecological and sociological impacts of increasing visitation has led to the implementation of a variety of wilderness management programs (Lucas 1973; Stankey 1979; Parsons and others 1981). These include site specific restrictions, increased emphasis on minimum impact education as well as the presence or absence of visitor facilities (Stankey and Baden 1977; Hendee and others 1978). In order to be effective, such programs must be based on detailed knowledge of the sensitivity of key ecosystems to varying use intensities, current and historical use levels, and an inventory of existing impacts. Together with an understanding of the management objectives for the area, such data provide the basis for defining acceptable impact levels as well as determining what management actions are needed to assure that unacceptable impacts do not occur.

In Sequoia and Kings Canyon National Parks, a large mountain wilderness in the southern Sierra Nevada of California, managers have been faced with the problem of how to protect the integrity of vulnerable natural ecosystems in the face of rapidly increasing use (Taylor 1972; Parsons 1983). The management system that has evolved is based on the concept of daily trailhead quotas that are determined by use capacities for each of 52 backcountry travel zones (Parsons and others 1981). The trailhead quota system is a form of external control that maximizes freedom to go where and stay as long as one wants once access to the area is obtained. The travel zones, which exist on paper only, serve as a tool to monitor visitor use levels and patterns.

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In this paper I review how a detailed inventory of the distribution and impact of campsites has provided the basis for determining use capacities for each of the Parks backcountry travel zones and how this information has been translated into an effective trailhead quota program. Comments are also offered on other uses for campsite inventory data.

CAMPSITES AS A BASIS FOR IMPACT MONITORING

Since campsites are areas of spatially and temporally concentrated use that are generally located in popular, highly visible and often ecologically sensitive sites, they are a logical focus for evaluating wilderness impacts. In fact, most of the systems available to document wilderness impacts use campsites as the principal index of resource damage (Hendee and others 1976; Bratton and others 1978; Frissell 1978; Parsons and MacLeod 1980; Cole 1983). As the primary focus of visitor activity, campsites provide a measure of biological and physical impacts as well as a reflection of crowding. Specific impacts can include trampling damage to tree roots and ground vegetation (Willard and Marr 1970; Frissell 1978), changes in plant species composition (Liddle 1975), changes in soil structure and chemistry (James and others 1979; Cole 1982), removal of downed wood from firewood gathering (Bratton and others 1982) and of unsightly fire rings, rock walls and other developments (Hammitt 1981).

Frissell (1978) has described a relatively constant pattern of camp site evolution with increasing use. This includes gradual increases in development, vegetation denudation, firewood consumption and soil damage with repeated use. Other investigators have shown that even light use can cause serious impacts (Frissell and Duncan 1965; Merriam and Smith 1974) and that such impacts can take a long time to recover (Willard and Marr 1971; Cole and Ranz 1983). Such studies emphasize the value of campsites as an effective and sensitive measure of wilderness impacts.

THE APPROACH

Zone Capacity Concept

The application of the carrying capacity concept to the wilderness setting has been the subject of much debate (Wagar 1974; Washburne 1982). Our use of campsites both as a primary indicator of use levels and impact and as a basis for establishing acceptable and appropriate conditions follows

logic developed by Stankey and others (1985) under the Limits of Acceptable Change System. This concept emphasizes understanding the management objectives and definition of desired conditions for an area in addition to the traditional physical or biological measurements of how much use the area can tolerate. It should be emphasized that the definition of what is acceptable is a management decision that must be based on legislation, policy and management objectives together with basic knowledge of the resources of the area (van Wagtendonk 1979; Stankey and others 1985).

In Sequoia and Kings Canyon National Parks the decision was made that while use restrictions would be implemented as trailhead quotas these values would be based on systematically determined use capacities for each of the Parks' backcountry travel zones. It was thus necessary to establish maximum use levels for each zone that would minimize environmental impacts while still providing the opportunity for a quality wilderness experience.

Maintenance of Historic Use Patterns

Sequoia and Kings Canyon contain a large number of widely dispersed backcountry campsites that have evolved over nearly a century of uncontrolled use. Recovery at such high elevation sites is extremely slow and new impacts are easily created (Parsons and DeBenedetti 1979; Stohlgren 1982). Based on this knowledge, the decision was made that a major management objective would be to maintain historical use patterns.

This approach attempts to assure that traditional low use (and generally low impact) areas will remain such. It recognizes the fact that relatively low levels of use are sufficient to maintain existing impacts and that heavily impacted areas will not show significant recovery without intensive (and expensive) rehabilitation efforts. The philosophy of maintaining historical use patterns to the extent unacceptable impacts do not occur recognizes the reality of slow recovery rates while preserving the opportunity to select from a variety of possible wilderness experiences (Clark and Stankey 1979). Since the distribution and impact of backcountry campsites reflects historical use patterns (Parsons 1983), campsites were selected as a principal basis for determining zone use capacities. Basic premises and assumptions used in the development of zone capacities are summarized in table 1.

Campsite Inventory Methods

A detailed field inventory of all backcountry campsites in Sequoia and Kings Canyon was carried out between 1977 and 1981. Each campsite was located and classified by impact class according to the methodology previously described by Parsons and MacLeod (1980). Campsites are defined as areas showing evidence of overnight use. This might include fire rings or cleared areas where tents or beds have been placed. The sites, which have evolved over nearly a century of repeated use and minimal management, are widely dispersed and of vastly differing size and character.

Table 1.--Basic premises and assumptions on which backcountry zone capacities are developed

1. It is generally desirable to maintain historical patterns of use dispersal and impact. Specifically, low use areas should not be permitted to become high use areas. Thus, zone capacities should not be based <u>solely</u> on the ability of an area to withstand use (ecological sensitivity) as such could cause significant redistribution of use, increased impact in traditional low use areas, and loss of opportunity for varied wilderness experiences.

2. The number and distribution of developed campsites (impact class 3, 4 and 5) relates to use levels and is one valid measure of impact.

3. There are more campsites than are ever used at any one time in a given area. It is thus possible to reduce the total number of sites available and still accommodate current peak demand.

4. Class 1 and 2 sites are used so seldom (generally 0 - 4 times a year) and show so little impact that they are omitted from consideration in capacity calculations. They do serve two purposes: (1) provide for choice of sites; (2) provide potential replacements for sites to be obliterated.

5. Since recovery rates in the Nevada Sierra are generally too slow to allow significant short term recovery without physical manipulation, reducing use levels by some percentage will not help recovery. Sites must be closed and rehabilitated if recovery is to occur.

6. Since education and behavior are important influences on use distribution and impact, efforts must be expanded in those areas.

7. No magic formulas exist for determining carrying capacities. Management subjectivity will always be necessary in determining "acceptable" conditions.

In carrying out the field inventory campsites were evaluated for factors related to site location, site development and observable physical and biological impacts. After being plotted on an area sketch map each campsite was evaluated for each of eight visually recorded criteria. These include density and composition of vegetation (in relation to surrounding undisturbed areas), total disturbed area of the campsite, area of barren core, campsite developments or improvements, litter and duff condition, number of social trails and extent of mutilations (Parsons and MacLeod 1980). Each criterion was assigned a rating based on a five point scale with a five representing maximum impact or diversion from natural conditions. The values are recorded for each applicable criterion, summed and divided by the number of criteria used to produce an overall

rating or "campsite class" for each site inventoried. A campsite class weighting system was developed to provide a meaningful comparison of impact levels between groups of sites (Parsons and Stohlgren in press).

A class 1 site generally represents no more than a small sleep site and possibly a small fire ring with little or no sign of trampling or impact to vegetation. A class 5 site is generally a large, heavily used barren area, often with numerous leveled sleep sites, fire rings and perhaps rock walls or mutilated trees. The criteria, rating scales and weighting system are fully documented elsewhere (Parsons and MacLeod 1980; Parsons and Stohlgren in press).

The individual campsite ratings were summarized by "management areas". Management areas are defined as nodes or concentrations of campsites within a zone. In practice these generally consist of individual lakes, stream segments or trail junctions. They represent geographically separable units upon which it is feasible to base management actions. Use capacities were determined for each management area, the sum of which represent the use capacity for a given zone.

Campsite Inventory Results

A total of 8,171 backcountry campsites were located and described in the two Parks. These were distributed among 273 management areas. The great majority (71.0 percent) of the campsites are small, class 1 or 2 sites. Only 349 (4.3 percent) are highly impacted class 5 sites. The number of campsites per zone is highly variable (range from 25 at Hamilton Lake to 323 at Rae Lakes), reflecting the variation in size, habitat and use levels found among the Parks' 52 backcountry travel zones.

The campsite inventory also provides data on the elevation, overstory and understory communities characteristic of each site or management area. These data are useful in evaluating the ecological sensitivity of specific areas. The inventory also records information on crowding (the number of other class 3, 4 and 5 sites within 100 feet) and the distance to water for each campsite. These data are useful in determining the ecological (sites too close to water increase chances of pollution) and sociological (crowded sites are less desirable) acceptability of specific campsites. Full descriptions of such campsite variables are presented elsewhere (Parsons and Stohlgren in press).

An example of a management area campsite inventory map is presented in figure 1. Each campsite location in the Lake Reflection management area is mapped along with its impact class rating. Additional information on the campsites in the Lake Reflection management area is provided in table 2.

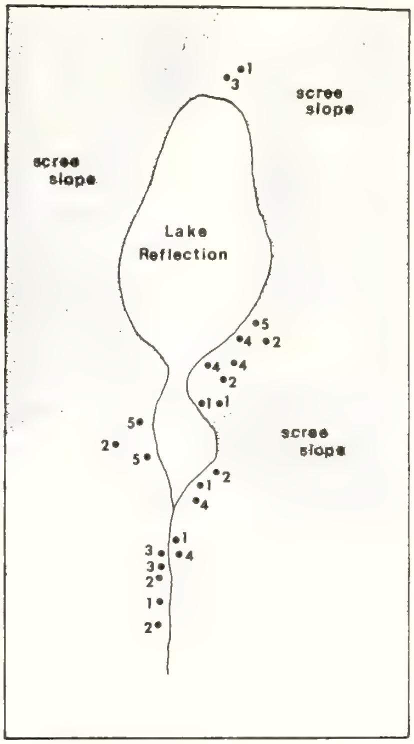

Figure 1.--Lake Reflection management area with campsites mapped by class.

Table 2.--Campsite characteristics for the Lake Reflection management area, elevation 10,000 feet. The overstory type is a mosaic canopy of mixed lodgepole pine (Pinus contorta ssp. murrayana) and foxtail pine (Pinus balfouriana)

Campsite Class	# Sites	# Sites by Distance to Water: 100ft+	25-100ft	0-25ft	# Crowded Sites[1]
1	6	2	3	1	0
2	7	3	2	2	0
3	3	0	1	2	0
4	4	1	2	1	1
5	3	0	1	2	1

[1]Number of class 3, 4, and 5 sites with another class 3, 4, or 5 site within 100 feet.

DEVELOPMENT OF ZONE CAPACITIES AND TRAILHEAD QUOTAS

Zone Capacities

The distribution of impacted (Class 3, 4 and 5) campsites was used as the basis for developing a first estimate of the number of acceptable

campsites in each backcountry travel zone. This number was then modified to incorporate available knowledge of historical use patterns, and the ecological and sociological sensitivity of the area to produce an optimal number of campsites that could be occupied at any one time without causing unacceptable impacts. Each management area was analyzed separately and the resultant number of optimal sites summed to produce a total number for the zone. This number was multiplied by the average party size to produce the use capacity in number of persons for each zone. The latter step was necessary to accommodate the computer model that translates zone capacities to trailhead quotas (Shechter and Lucas 1978). While the location and development of individual campsites provided the basis for discussion, the subjective judgment of scientists and managers most familiar with the specific areas played an important role in determining final use capacities. For while scientific data can provide valuable input into the consequences of varying use levels or behavior patterns the final choice of what impacts are acceptable must remain a management decision.

In practice, the numbers of class 3, 4 and 5 sites for each management area were tallied and those that were within 25 feet of water, within 100 feet of another class 3, 4, or 5 site, or were noted in the field inventory form comment section to be unacceptable for other reasons (e.g., on sensitive meadow vegetation) were dropped from consideration. The remaining sites represented the maximum number of sites that could be occupied at any one time. Class 1 and 2 sites are generally used so infrequently that they were omitted from all calculations. It was recognized that they would continue to be used, providing both a choice of sites on any given night and a selection of sites that could be developed as replacements for unacceptable sites should such be needed.

A team consisting of park scientists, resource managers, backcountry rangers and administrators familiar with the area carefully reviewed the remaining site dispersal for each management area. In many cases it was obvious that many more acceptable sites were available than would ever be occupied on any given night without greatly exceeding either the peak recorded use or the subjective judgment of what use level was acceptable. There then followed a detailed review and discussion of the location and sensitivity of each campsite. Based on consideration of local use patterns, preferences for dispersal, physical limitations of the area, and such special concerns as sanitation or rare species protection, a consensus was reached on the maximum number of sites that could be occupied on a given night without causing unacceptable crowding or resource impact. These numbers were compared with available information (from wilderness permits and backcountry ranger counts) on the number of parties using specific areas during peak use periods between 1976 and 1980. If the number of sites to be occupied exceeded the recorded peak use it was reduced accordingly. This was primarily a paper exercise; in practice the excess sites would remain available to accommodate occasional heavy demand and provide for a choice of sites. Inappropriate sites are being rehabilitated as time and funds permit. In developing these numbers it was recognized that the QUOTA computer model that would be used to translate the zone capacities into trailhead quotas works on averages (van Wagtendonk and Coho 1985). Thus actual use levels of specific zones can be expected to fluctuate as much as 30 percent or more around the established capacities. This assures considerable flexibility in accommodating future shifts in use trends or dispersal patterns from given trailheads.

Since the QUOTA model requires zone capacities to be input as number of people rather than parties, the optimum number of parties (or sites that can be occupied simultaneously) was converted into a number of persons per night by multiplying by 3.4, the average party size over the past five years. Recognizing that heavy use days usually result from the presence of one or more large parties, this number was then selectively increased to allow for one or more large groups (15 persons) depending on the ability of the zone to accommodate them. This decision was based on the historical propensity of zones to attract large groups as well as data from the campsite inventory forms identifying potential large group sites in each management area.

Finally, since the QUOTA model is based on travel patterns entered on wilderness permits and since these routes are projected at the beginning of a trip it was necessary to make corrections in those cases where projected use levels markedly differ from actual use. Those zones which consistently receive five or more percent more or less use than that projected on wilderness permits had the capacities adjusted according to available permit validity data (Parsons and others 1982).

In the Lake Reflection management area example (table 3) 11 of the 23 total sites are identified as class 3, 4, or 5. Of the eleven, five are too close to water and one other is located too close to another site. This leaves five acceptable sites. The review meeting resulted in the consensus decision that, on the average, no more than four sites should be occupied at any one time

Table 3.--Campsite inventory data for the Lake Reflection and East Lake management areas

Management Area	Total Campsites	Total # 3, 4, & 5 sites	Acceptable #3, 4, & 5's	Optimum # 3, 4, & 5's
Lake Reflection	23	11	5	4
East Lake	37	18	9	4
Zone Total	60	29	15	8

if the "wilderness experience" was to be maintained. When these four sites are added to the four from the other management area in the zone (table 3) a total of eight is obtained as the optimal number of sites to be occupied in the zone at any one time. This translates to a capacity of 27 persons. However, since the Lake Reflection zone attracts and is able to accommodate large groups, an additional 12 persons (one large group) were added to the capacity to total 39. This compares with recorded peak use levels in the zone of 12 parties and 34 people between 1976 and 1980. For Lake Reflection, no corrections were needed to account for discrepancies between wilderness permit validity and actual use levels.

Trailhead Quotas

Once the zone capacities were determined they were entered into the QUOTA computer simulator model developed by van Wagtendonk and Coho (1985) at Yosemite National Park. The QUOTA model relates zone use and capacities to trailhead use in such a way that it determines what daily trailhead quotas would be required to assure that zone capacities are not exceeded. Since certain zones can act as bottlenecks that restrict use below capacity in other zones, the model was also run in reverse to predict what zone use levels could be expected should the proposed quotas be implemented. Since the capacities are based on average party size and the model simulation is based on average routes it must be realized that resulting use levels may vary considerably from day to day.

EXPERIENCE TO DATE

Daily trailhead quotas have been in effect for Sequoia and Kings Canyon National Parks since 1975. The original quotas served as interim numbers designed to maintain the 1971-72 use levels until a more quantitative basis for determining capacities could be developed. The revised trailhead quotas based on the system described here were implemented in 1982. Each year zone capacities and trailhead quotas are reviewed and, if necessary, revisions made. As it is now configured the QUOTA model may restrict use from a trailhead as soon as the capacity of one of its major feeder zones is reached. This can unnecessarily restrict use in other zones fed by that trailhead (van Wagtendonk and Coho 1985). In addition, a number of traditional high use zones show such severe resource problems that they cannot be expected to recover without special attention. These problems have been dealt with through a combination of such management actions as one night camp limits, area closures and designation of "bypass" quotas that allow users to pass through zones that have otherwise reached their capacity without spending the night (Parsons 1983; van Wagtendonk and Coho 1985).

To date, the program of controlling backcountry use by trailhead quotas that in turn are determined by campsite based zone use capacities has been well received by the user public. In a survey of wilderness users at park trailheads Kantola (1977) found strong support for using such management options as trailhead quotas. Public meetings held in March of 1985 to review the new backcountry management plan for the Parks have resulted in strong support for the program from all major user groups.

OTHER USES OF CAMPSITE DATA

In addition to forming the basis for the zone use capacity and trailhead quota determinations, the campsite impact data collected for Sequoia and Kings Canyon provide valuable baseline information on the nature and extent of visitor impacts. For example, together with available use figures, data on the number and concentration of campsites of different impact classes in various elevation zones or community types can provide insight into the relative sensitivity to impact characteristic of such areas. Data on the number of crowded, illegal or inappropriate campsites provide a basis for scheduling crews to carry out rehabilitation work.

Information on the number of camp sites as well as their condition and distribution, forms a basis for evaluating the "acceptability" of conditions as well as formulating management strategies. Once management has defined "acceptable" conditions the data provide a basis for determining whether those standards have been met (Cole 1983). It also can provide guidance in determining what management actions are most appropriate should conditions not be acceptable. Perhaps most important, campsite inventory data provide a reference point for monitoring programs to evaluate future trends in the dispersal and magnitude of wilderness impacts. Such is essential in evaluating long term trends in visitor impacts and ecosystem health.

CONCLUSIONS

The concept of using campsite impact data as the basis for determining use capacities and trailhead quotas has been well received. While any decision on what constitutes "acceptable" impacts or use levels must by nature be arbitrary, the idea of using quantitative field data to guide such decisions makes them both more understandable and defensible (Cole 1983). The use of campsite data is just one of many possible methods for guiding use capacity decisions. Alternative methods include risk zoning (Greist 1975), computer simulation (van Wagtendonk 1979), evaluation of physical limits or ecological sensitivity (van Wagtendonk 1985), and sociological concerns (Stankey 1973).

The use of campsite impacts as a basis for determining use restrictions has both strengths and weaknesses. In many high elevation areas the distribution and impact of campsites is in large part a reflection of historical use patterns. In such cases reducing use levels on heavily impacted sites will do little to improve conditions (Cole 1981). Thus, unless intensive rehabilitation is planned, it is often necessary to accept existing

impacts. Under such conditions reduction of use may have little justification based on physical or ecological considerations. On the other hand, since many areas have more campsites than have ever been used at the same time a decision must be made on whether active steps will be taken to increase historical use levels to fully utilize the available space. The decision in Sequoia and Kings Canyon to maintain historical patterns of use was a conscious effort to minimize the development of new impacts while assuring a choice of possible experiences. This contrasts with the decision made in some wilderness areas to base capacities entirely on physical or ecological parameters. If such a system were applied in Sequoia and Kings Canyon it would lead to relatively equal use intensities throughout the Parks. This would both increase impacts in traditional low use areas and reduce the opportunity to visit such areas (since they would no longer be low use).

The campsite impact data base provides a valuable tool for evaluating future trends. As additional data become available the zone capacities can be re-evaluated and adjusted to better reflect such changes or to respond to adjustments in "acceptable" standards. The campsite impact data provide a flexible, potentially expandable data base that can be used as a basis for management decisions for years to come.

REFERENCES

Bratton, Susan Power; Hickler, Matthew G.; Graves, James H. Visitor impact on backcountry campsites in the Great Smoky Mountains. Environ. Manage. 2: 431-432; 1978.

Bratton, Susan Power; Strombert, L. L; Harmon, M. E. Firewood-gathering impacts in backcountry campsites in Great Smoky Mountains National Park. Environ. Manage. 6: 63-71; 1982.

Clark, Roger N.; Stankey, George H. Determining the acceptability of recreational impacts: an application of the Outdoor Recreation Opportunity Spectrum. In: Ittner, Ruth; Potter, Dale R.; Agee, James K.; Anchell, Susie, eds. Recreational impact on wildlands symposium: proceedings; 1978 October 27-29; Seattle, WA. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979: 32-42.

Cole, David N. Managing ecological impacts at wilderness campsites: an evaluation of techniques. J. Forestry. 79(2): 86-89; 1981.

Cole, David N. Wilderness campsite impacts: effects of amount of use. Res. Paper INT-284. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 34 p.

Cole, David N. Monitoring the condition of wilderness campsites. Res. Paper INT-302. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 10 p.

Cole, David N.; Ranz, Beth. Temporary campsite closure in the Selway-Bitteroot Wilderness. J. Forestry. 81(11): 729-732; 1983.

Frissell, Sidney S. Judging recreation impacts on wilderness campsites. J. Forestry. 76(8): 481-483; 1978.

Frissell, Sidney S. Jr.; Duncan, Donald P. Campsite preference and deterioration in the Quetico-Superior canoe country. J. Forestry. 63(4): 256-260; 1965.

Greist, David A. Risk zoning - a recreation area management system and method of measuring carrying capacity. J. Forestry. 73(11): 711-714; 1975.

Hammitt, William E. Fire-rings in the backcountry - are they necessary? Parks. 5(4): 8-9; 1981.

Hendee, John C.; Clark, Roger N.; Hogans, Mark L.; Wood, Dan; Koch, Russell W. Code-A-Site: a system for inventory of dispersed recreational sites in roaded areas, backcountry, and wilderness. Research Paper PNW-209. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1976. 33 p.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Misc. Publ. No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

James, T. D. W.; Smith, D. W.; Mackintosh, E. E.; Hoffmann, M. K.; Monti, P. Effects of camping recreation on soil, jack pine, and understory vegetation in a northwestern Ontario park. For. Sci. 25: 333-349; 1979.

Kantola, William W. Opinions and Preferences of Visitors Toward Alternatives for Limiting Use in the Backcountry of Sequoia and Kings Canyon National Parks. Eugene, OR: University of Oregon; 1977. 87 p. M.S. Thesis.

Liddle, M. J. A selective review of the ecological effects of human trampling on natural ecosystems. Biol. Conserv. 7: 17-36; 1975.

Lucas, Robert C. Wilderness: a management framework. J. Soil. and Water Conserv. 28(4): 150-154; 1973.

Merriam, L. C., Smith, C. K. Visitor impact on newly developed campsites in the Boundary Water Canoe Area. J. Forestry. 72(10): 627-630; 1974.

Parsons, David J.; DeBenedetti, Steven H. Wilderness protection in the high Sierra: Effects of a 15-year closure. In: Linn, Robert M., ed. First Conference on Scientific Research in the National Parks: proceedings 1976 November 9-12; New Orleans, LA. Trans. and Proc. Series No. 5. Washington, DC: U.S. Department of Interior, National Park Service; 1979: 1313-1318.

Parsons, David J. Wilderness protection: an example from the southern Sierra Nevada, USA. Environ. Conserv. 10(1): 23-30; 1983.

Parsons, David J.; MacLeod, Susan A. Measuring impacts of wilderness use. Parks. 5(3): 8-12; 1980.

Parsons, David J.; Stohlgren, Thomas J. Impacts of visitor use on backcountry campsites in Sequoia and Kings Canyon National Parks. Technical Report. San Francisco, CA: U.S. Department of Interior, National Park Service, Western Region; [in press].

Parsons, David J.; Stohlgren, Thomas J.; Kraushaar, James M. 1982. Wilderness permit accuracy: differences between reported and actual use. Environ. Manage. 6: 329-335; 1982.

Parsons, David J.; Stohlgren, Thomas J.; Fodor, Paul A. Establishing backcountry use quotas: an example from Mineral King, California. Environ. Manage. 5: 335-340; 1981.

Shechter, Mordechai; Lucas, Robert C. Simulation of Recreational Use for Park and Wilderness Management. Baltimore, MD: Johns Hopkins University Press. 1978. 220 p.

Stankey, George H. Use rationing in two southern California wildernesses. J. Forestry. 77(5): 347-349; 1979.

Stankey, George H; Baden, John. Rationing Wilderness Use: Methods, Problems, and Guidelines. Research Paper INT-192. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 20 p.

Stankey, George H. Visitor perception of wilderness recreation carrying capacity. Research Paper INT-242. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 34 p.

Stankey, George H.; Cole, David N.; Lucas, Robert C.; Peterson, Margaret E.; Frissell, Sidney S. The limits of acceptable change (LAC) system for wilderness planning. Gen Tech Report INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

Stohlgren, Thomas J. Vegetation and soil recovery of subalpine campsites in Sequoia National Park. Fresno, CA: California State University. 1982. 49 p. M. A. Thesis.

Taylor, Ronald B. No vacancy in the wilderness. Sierra Club Bull., 67(9): 5-8; 1972.

van Wagtendonk, Jan W. A conceptual backcountry carrying capacity model. In: Linn. Rorbert, M; ed. First Conference on Scientific Research in National Parks: proceedings 1976 November 9-12; New Orleans, LA. Transactions and Proceedings Series 5. Washington, DC: U.S. Department of Interior, National Park Service: 1033-1038.

van Wagtendonk, Jan W. The determination of carrying capacities for the Yosemite wilderness. In these Proceedings.

van Wagtendonk, Jan W.; Coho, Paul R. Establishing and implementing trailhead quotas for the Yosemite Wilderness. J. Forestry. 1985. (in press).

Wagar, J. Alan. Recreational carrying capacity reconsidered. J. Forestry. 72(5): 274-278; 1974.

Washburne, Randel F. Wilderness recreational carrying capacity: are numbers necessary? J. Forestry. 80: 726-728; 1982.

Willard, Beatrice E.; Marr, John W. Recovery of alpine tundra under protection after damage by human activities in the Rocky Mountains of Colorado. Bio. Conserv. 3(3): 181-190; 1971.

Willard, Beatrice E.; Marr, John W. Effects of human activities on alpine tundra ecosystems in Rocky Mountain National Park, Colorado. Biol. Conserva. 2(4): 257-265; 1970.

THE DETERMINATION OF CARRYING CAPACITIES FOR THE YOSEMITE WILDERNESS

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ABSTRACT: As a result of dramatically increasing visitation and resultant impacts, carrying capacities were needed for the Yosemite Wilderness. These capacities were based on the number of acres in a wilderness travel zone, the miles of trail it contained, and its ecological fragility. They were implemented on an interim basis until a more refined approach could be developed.

INTRODUCTION

During the late 1960's and early 1970's, the wilderness areas of Yosemite National Park experienced a phenomenal increase in visitation (van Wagtendonk 1981). Prior to 1972, use figures were derived from voluntary fire permits. Although subjective estimates of total use could be made, there was no way to determine their accuracy. Implementation of a mandatory permit system in 1972 for all over-night users made managers aware for the first time of the magnitude of wilderness use. Field observations had found trampled vegetation in the most popular areas, eroded and multiple trails throughout the wilderness, and up to 200 people camped around subalpine lakes on weekends. In order to quantify these impacts, an inventory of all wilderness campsites and trails was conducted (Holmes and others 1972).

Based on information from wilderness permits and the impact inventory, park managers felt that immediate action was necessary. The first step was to review the literature to determine available approaches and information needs. Next, a research program was initiated to fill gaps in knowledge in both the sociological and ecological fields. Finally, since use had obviously exceeded acceptable levels in some areas, interim capacities were needed until more refined limits could be derived through research.

At that time, the wilderness carrying capacity literature was just beginning to grow. The concept had been introduced decades before by Lowell Sumner, a wildlife technician studying impacts in Yosemite and Sequoia National Parks. He stated that, "...there is a positive saturation point beyond which further concentration of people will destroy the very thing which they seek..." (Sumner 1936). Interestingly enough he felt that, even then, that point had been reached in some areas of Yosemite.

Wagar (1964) had explored the concept of recreational carrying capacity and concluded that it was a complex matter that required difficult value judgments by managers based on the desires of recreationists and the ecological characteristics of the area. Research by Lucas (1964) on wilderness quality and La Page (1967) on campsite trampling emphasized that simple numerical measures of use were not sufficient for predicting impacts. Lime (1970) recognized this limitation and proposed using the acceptability of human-caused changes to the wilderness experience and resource as a determinant of capacity. This concept was expanded upon and became known as the Limits to Acceptable Change (LAC) model (Frissell and Stankey 1972; Lime and Stankey 1971). Although this model has since been formalized as a wilderness planning system by Stankey and others (1985), the methodology was not available in 1972.

The research program begun in 1973 focused on sociological and ecological studies. Lee (1975, 1977) and Absher and Lee (1978, 1981) analyzed sociological carrying capacity and concluded that the range of social norms and settings was so diverse that no definitive limits could be derived. Parmeter (1976) headed a group that investigated ecological carrying capacity including studies of human impacts on vegetation, soil, water and microclimates. They also concluded that the relationship between use and impact depended on numerous other variables and that the determination of an acceptable level of impact was a subjective decision. These studies, as well as most others dealing with carrying capacity, underscored the need for clear management objectives when setting acceptable levels of impact and use. The final decision on capacity must be made by managers based on the best available information.

Since interim capacities were needed for the 1973 summer season, the approach was to use existing data and a familiarity with the Park's wilderness ecosystems to reach a decision. Specifically, it was hypothesized that a capacity for each area of the wilderness could be determined from available density guidelines and mapped information. This paper reports on that effort.

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METHODOLOGY

Initial capacities were set for each area of 52 wilderness travel zones based on a method suggested by Linn (1972). The zones roughly corresponded with drainages and averaged just under 15,000 acres in size. Density guidelines were first applied to the number of acres and miles of trail in each zone. These values were then reduced by a fragility factor which rated the capability of the ecosystem type to withstand use. The travel zones, trails and ecosystem types are depicted in figure 1. The ecosystem types are generally described as montane, subalpine, and alpine.

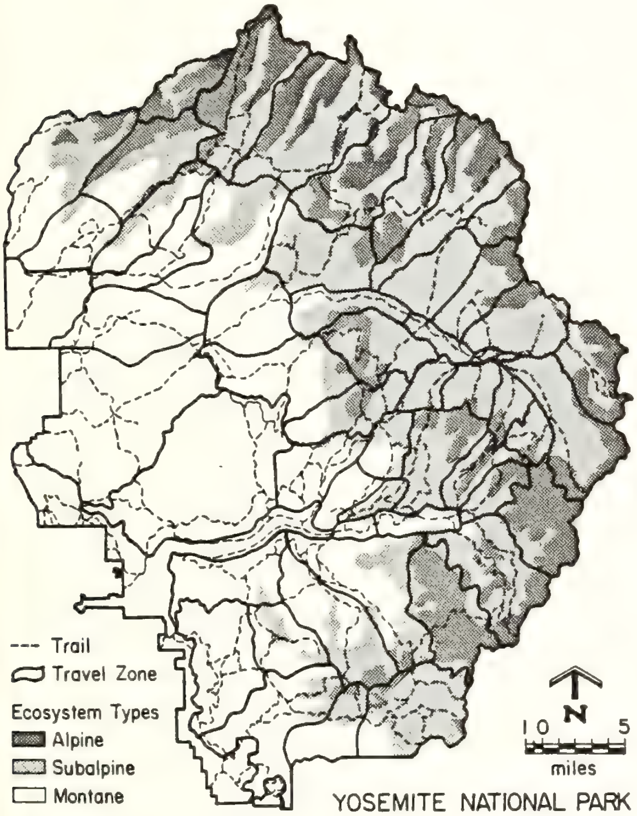

Figure 1.--Travel zones, trails, and ecosystem types in the Yosemite Wilderness.

The montane forests contain mixtures of species roughly corresponding to elevational belts. As elevation increases, pure ponderosa pine (Pinus ponderosa) stands become mixed with incense-cedar (Calocedrus decurrens), sugar pine (P. lambertiana), and white fir (Abies concolor). This mixture gives way to pure stands of red fir (A. magnifica) at the upper part of the montane type, with Jeffrey pine (P. jeffreyii), western white pine (P. monticola), and western juniper (Juniperus occidentalis) occurring on exposed ridges. The subalpine forests are predominantly lodgepole pine (P. contorta) and as timberline is approached, it is replaced by mountain hemlock (Tsuga mertensiana) and whitebark pine (P. albicaulis). The alpine type consists of fell fields containing herbs, sedges, and grasses and willow (Salix sp.) shrublands.

Social Density

While space standards often are not based on sociological or ecological research, they have developed from intuitive judgment and field experience (Lime and Stankey 1971). As such, they represent a "first cut" for determining carrying capacity and should be refined when research studies relating density to satisfaction and ecological impact become available. Again, it should be emphasized that those relationships are by no means well established (Absher and Lee 1981; Heberlein 1977).

The National Park Service (1959) had previously established density standards for parks, wilderness, nature preserves, and scientific monuments. For wilderness, the standard was one visitor per season for every acre. Since the use season in Yosemite is approximately 100 days, this comes out to .01 persons per acre per day. It should be realized, of course, that in a typical 20,000-acre zone, most of the people would concentrate in four or five camp areas.

Since trails tend to disperse use, an increase in trail mileage would increase the ability of a zone to absorb additional visitors. For this analysis it was assumed that each mile of trail in a zone increases the zone capacity by two people. This is roughly equivalent to a one-third increase in capacity for each mile of trail per square mile of area in a zone. While no empirical basis existed for this assumption when it was made, computer simulations have shown that the expansion of a trail network will result in reduced trail and camp area encounters and use levels, thereby increasing the ability of the area to accommodate more use (Shechter and Lucas 1978).

Ecological Fragility

The capability of each travel zone to withstand use was evaluated using four of the five factors described by Linn (1972). The ecological resources of each zone were first rated from 0 to 9 for: (1) rarity, (2) vulnerability, (3) recuperability, and (4) repairability, with 0 being common, not vulnerable, easily repaired, and extremely capable of recuperation and 9 being unique, very vulnerable, not easily repaired, and not capable of recuperation. If a zone included more than one ecosystem type, the ratings were weighted by the proportional areas of those types. The fifth factor, replicability, was not rated since it seemed inappropriate to try to reproduce ecosystems in wilderness.

Rarity is defined as the uniqueness of a particular ecosystem type or ecological community. The ecosystem types were given values equal to the reciprocal to the nearest whole number of their percent of coverage of the wilderness

divided by 100. For example, the montane type occupies 45 percent and received a rating of two, as did the subalpine type (41 percent). The alpine type (14 percent) was assigned a seven. Special unique types might also be given high ratings regardless of area. For instance, giant sequoia (Sequoiadendron giganteum) groves occur in only three locations within the montane type and are considered locally rare, rating an eight. Ecosystems containing threatened or endangered species would rate a nine.

Vulnerability is defined as the susceptibility of ecological resources to damage by humans. Sharsmith (1961) reported on the status, changes, and comparative ecology of selected backcountry areas in Yosemite National Park. He stated that alpine types were the most vulnerable followed by subalpine, and then montane. Willard and Marr (1970) studied alpine ecosystems in Rocky Mountain National Park and estimated that impacts became prominent after only 12 weeks of use. A study by Dykema (1971) in Sequoia National Park reiterated these results concluding that alpine areas suffered large decreases in herbaceous cover compared to lower elevation types. Based on these studies, relative impact rates of 0.5, 1.0, and 2.0 years were selected for alpine, subalpine, and montane types, respectively. In order to derive vulnerability scores over the desired range, the reciprocals of the impact rates were multiplied by four to give scores of 8 for alpine types, 4 for subalpine types, and 2 for montane types.

Recuperability is the ability of an ecological system to recover unassisted by humans. Willard and Marr (1971) estimated that it would take several hundred and possibly even a thousand years for ecological processes to bring about full recovery of alpine tundra. Estimates substantiated by later research by Ranz (1979) and Parsons and DeBenedetti (1979) are from 10 to 20 years for subalpine types and five years for montane types. If 500 years is chosen as the recovery period for alpine types, 15 for subalpine types, and 5 for montane types, the recuperability scores can be determined from their powers to the base of two. Rounded these would be 9, 4, and 2, respectively.

Repairability is the ability of an ecosystem to be restored once it has been impacted. Numerous studies addressed the success of efforts to revegetate campgrounds in conifer forests (Beardsley and Wagar 1971; Herrington and Beardsley 1970; Jollif 1969; Thalheimer 1967), subalpine ranges (Ellison 1949; Smith 1963), and high-altitude barren slopes (Gates 1962; Harrington 1946; McClelland 1972). Although different treatments were applied and success varied, the time necessary for restoration increased as elevation increased and growing season shortened. Since precipitation is generally adequate within the three ecosystem types in Yosemite, the number of frost-free days was used to approximate repairability. The alpine areas averaged 50 frost-free days per year, subalpine 100 days, and montane 150 days. The reciprocals of these values were multiplied by 400 to derive scores of 8, 4, and 3.

Capacity Calculation

The maximum carrying capacity for a zone is calculated from the social density, the acres in the zone, and an adjustment for the number of miles of trail per square mile in the zone:

$$A = .01\ (\text{acres}) * [1 + .33\ (\text{miles/square mile})],$$

where A is the maximum number of people. This value is then reduced by the fragility factor which is calculated by adding up the fragility scores and dividing by 36 (the maximum rating):

$$B = \left(\sum_{i=1}^{4} \text{Score}_i\right)/36.$$

These values are then combined in an equation similar to the one suggested by Linn (1972):

$$CC = A - (B*A),$$

where CC is the carrying capacity in people for the zone.

Table 1 shows the calculations for the fragility factor (B) for one zone in each ecosystem type. For Yosemite, zones in the montane type have their capacities reduced by 25 percent, subalpine zones by 39 percent, and alpine zones by 78 percent.

Table 1.--Calculation of the fragility factor (B) for example montane, subalpine, and alpine zones

	Fragility Scores					B
Ecosystem Type	Rarity	Vulnerability	Recuperability	Repairability	Sum	(sum/36)
Montane	2	2	2	3	9	.25
Subalpine	2	4	4	4	14	.39
Alpine	7	8	9	8	32	.78

The density and fragility factors are combined in table 2. The larger, more extensively trailed subalpine zone had the greatest capacity while the fragile, little-trailed alpine zone had the smallest capacity.

Table 2.--Calculation of carrying capacity (CC) for example montane, subalpine, and alpine zones

Ecosystem Type	Area		Trails	A	B*A	CC
	Acres	Miles^2	Miles			
Montane	19,968	31	11	222	55	166
Subalpine	31,910	50	24	365	142	223
Alpine	18,208	28	4	190	148	42

FINDINGS

This process was used prior to the 1973 summer season to derive capacities for the Yosemite Wilderness. The result was a total capacity of 4,019 people at one time for all 45 zones. The zone capacities were then presented to the rangers who had the responsibility for managing the wilderness, and they adjusted them based on experience, ease of administration, and predicted public acceptance. In general, they were rounded up to the nearest multiple of 25 to accommodate the maximum allowable group size, and in the case of one heavily used zone increased by 135. This zone had two resident rangers, chemical toilets, and designated camp-sites and it was felt that those measures could mitigate the impacts from additional users.

During the 1973 use season, wilderness permits were used to keep track of the number of people anticipated in each zone each night. A party requesting a permit which included an overnight stay in a zone already at its capacity was informed that it was full. Alternative zones were suggested although the party could still choose their original route. In subsequent years, the use limits were strictly enforced and once a zone had reached its capacity, no additional permits for use in that zone were issued. Parties were then rerouted to avoid zones that were at capacity.

As an interim measure, the capacities were successful. Efforts to manage visitor use has eased and the excessive temporal and spatial peaks in use were reduced even though total use increased during the first three years after implementation (van Wagtendonk 1981). Subsequent reductions in total use have been attributed to a general decline in the popularity of backpacking in the Sierra Nevada.

Visitor acceptance of the limits has been high. A questionnaire administered by the National Park Service (1976) showed that 86 percent of the respondees favored a use limit and permit system while only 4 percent thought there should be neither limits or permits. Absher and Lee (1978) found no opposition to limits and an 88 percent positive response to the need for permits.

In order to assess the effects of shifts of use on resources, a monitoring program was begun. Campsite and trail impacts are being recorded throughout the wilderness for comparison with the earlier survey (Holmes and others 1972). These data will enable managers to further refine the system.

MANAGEMENT AND RESEARCH IMPLICATIONS

Perhaps the most important conclusion to come from this study is that interim carrying capacities can be derived from existing information and a familiarity with the ecosystems involved. These capacities can be implemented immediately to reduce overuse problems without waiting for research results.

The research effort that was initiated at the same time as the capacities did not result in significant changes in them. Although more refined data were collected on ecological and sociological impacts, the amount of management control necessary to restrict use to a specific level would be excessive. For instance, although it is possible to predict the number of footsteps required to trample a plant beyond recovery, it would not be desirable to have rangers count each step and not allow that last step to fall. The practicality of measuring by the inch what you only want to control by the mile must be questioned.

The capacities determined by the methods described have proven to be effective and are accepted by visitors and managers. When a decision to limit use must be made, this method can provide an interim solution. A further benefit is that field testing has shown that the values were adequate and that additional research was not necessary.

REFERENCES

Absher, James D.; Lee, Robert G. Analysis of sociological carrying capacity for the Yosemite National Park backcountry: Final research report. San Francisco: U.S. Department of Interior, National Park Service, Western Region; 1978. 57 p.

Absher, James D.; Lee, Robert G. Density as an incomplete cause of crowding in backcountry settings. Leisure Sciences. 4(3): 231-248; 1981.

Beardsley, Wendell G.; Wagar, J. Alan. Vegetation management on a forested recreation site. Journal of Forestry. 69(10): 728-731; 1971.

Dykema, J. A. Ecological impact of camping upon the southern Sierra Nevada. Los Angeles: University of California; 1971. 156 p. Ph.D. dissertation.

Ellison, L. Establishment of vegetation on depleted subalpine range as influenced by microenvironment. Ecological Monographs. 19: 95-121; 1949.

Frissell, Sidney S.; Stankey, George H. Wilderness environmental quality: search for social and ecological harmony. Proceedings of the Society of American Foresters; 1972 October 1-5; Hot Springs, AR. Washington, DC: Society of American Foresters; 1972: 170-183.

Gates, D. H. Revegetation of high altitude barren slopes in northern Idaho. Journal of Range Management. 15: 314-318; 1962.

Harrington, H. D. Results of seeding experiment at high altitudes in the Rocky Mountain National Park. Ecology. 27(4): 375-377; 1946.

Heberlein, Thomas A. Density, crowding, and satisfaction: sociological studies for determining carrying capacities. Proceedings: river recreation management and research symposium; 1977. General Technical Report NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 67-76.

Herrington, R. B.; Beardsley, W. G. Improvement and maintenance of campground vegetation in central Idaho. Research Paper INT-87. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1970. 9 p.

Holmes, Daniel O.; Akeson, Stephen; DeBenedetti, Steven H.; Holmes, Joseph E.; Paine, Marguerite; Parker, Anne Z.; Such, Timothy F. Yosemite backcountry inventory, summer 1972. 1972. Unpublished report on file at: U.S. Department of Interior, National Park Service, Yosemite National Park, Research Center, El Portal, CA. 2295 p.

Jollif, G. D. Campground site-vegetation relationships. Fort Collins, CO: Colorado State University; 1969. 139 p. Ph.D. dissertation.

La Page, Wilber I. Some observations on campground trampling and ground cover response. Research Paper NE-68. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1967. 11 p.

Lee, Robert G. The management of human components of the Yosemite National Park ecosystem. Yosemite National Park, CA: The Yosemite Institute; 1975. 134 p.

Lee, Robert G. Alone with others: the paradox of privacy in wilderness. Leisure Sciences. 1(1): 3-20; 1977.

Lime, David W. Research for determining use capacities of the Boundary Waters Canoe Area. Naturalist. 21: 8-13; 1970.

Lime, David W.; Stankey, George H. Carrying capacity: maintaining outdoor recreation quality. In: Recreation Symposium Proceedings; 1971; Upper Darby, PA. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1971: 174-184.

Linn, Robert M. Carrying capacity. 1972. Unpublished paper on file at: U.S. Department of Interior, National Park Service, Yosemite National Park, Research Center, El Portal, CA. 9 p.

Lucas, Robert C. Wilderness perception and use: the example of the Boundary Waters Canoe Area. Natural Resources Journal. 3(3): 394-411; 1964.

McClelland, B. Reily. Logan Pass seeding experiment. 1972. Unpublished report on file at: U.S. Department of Interior, National Park Service, Glacier National Park, West Glacier, MT. 5 p.

Parmeter, John R., principal investigator. (University of California, Berkeley). Ecological carrying capacity research: Yosemite National Park. 4 vol. Available from: NTIS, Springfield, VA 22161; paper copy $20.00; PB270954AS. Written in 1976.

Parsons, David J.; DeBenedetti, Steven H. Wilderness protection in the High Sierra: effects of a 15-year closure. In: Linn, Robert M., ed. Proceedings of the First Conference of scientific research in the national parks; 1976 November 9-12; New Orleans, LA. Transactions and Proceedings Series 5. Washington, DC: U.S. Department of Interior, National Park Service; 1979: 1313-1318.

Ranz, Beth. Closing wilderness campsites: visitor use problems and ecological recovery in the Selway-Bitterroot Wilderness. Missoula, MT: University of Montana; 1979. 125 p. M.S. thesis.

Sharsmith, Carl W. A report on the status, changes, and comparative ecology of selected backcountry meadows in Yosemite National Park. 1961. Unpublished paper on file at: U.S. Department of Interior, National Park Service, Yosemite National Park, Research Library, Yosemite National Park, CA. 58 p.

Shechter, Mordechai; Lucas, Robert C. Simulation of recreational use for park and wilderness management. Baltimore, MD: Johns Hopkins University Press; 1978. 220 p.

Smith, J. G. A subalpine grassland seeding trial. Journal of Range Management. 16: 208-210; 1963.

Stankey, George H.; Cole, David N.; Lucas, Robert C.; Peterson, Margaret E.; Frissell, Sidney S. The Limits of Acceptable Change (LAC) system for wilderness planning. General Technical Report INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

Sumner, E. Lowell, Jr. Special report on a wildlife study of the High Sierra in Sequoia and Yosemite National Parks and adjacent territory. San Francisco: U.S. Department of Interior, National Park Service, Western Region; 1936. 61 p.

Thalheimer, J. F. A test of rotated use, watering and seeding for maintaining vegetation under simulated recreational use. Logan, UT: Utah State University; 1967. 51 p. M.S. thesis.

U.S. Department of Interior, National Park Service. Guidelines for determination of needs for parks, other natural areas and recreation areas. Washington, DC: U.S. Department of Interior, National Park Service; 1959. 3 p.

U.S. Department of Interior, National Park Service. Planning workbook results. Denver, CO: U.S. Department of Interior, National Park Service, Denver Service Center; 1976. 44 p.

van Wagtendonk, Jan W. The effects of use limits on backcountry visitation trends in Yosemite National Park. Leisure Sciences. 4(3): 311-323; 1981.

Wagar, J. Alan. The carrying capacity of wildlands for recreation. Forest Science Monograph 7; 1964. 24 p.

Willard, Beatrice E.; Marr, John W. Effects of human activities on alpine tundra ecosystems in Rocky Mountain National Park, Colorado. Biological Conservation. 2(4): 257-265; 1970.

Willard, Beatrice E.; Marr, John W. Recovery of alpine tundra under protection after damage by human activities in the Rocky Mountains of Colorado. Biological Conservation. 3(3): 181-190; 1971.

A SITE ANALYSIS APPROACH FOR DETERMINING WILDERNESS CARRYING CAPACITY

Michael R. Kania

ABSTRACT: Reviews the process of determining carrying capacity for the Soldier Lakes Basin in the Frank Church--River of No Return Wilderness on the Challis National Forest. The emphasis is on presenting a quick method for developing carrying capacity limits on the Ranger District level for the newly created Wilderness. Field investigation and a literature review were used to discount those aspects of carrying capacity that are not significant in the area and to concentrate on those that were. Ecological carrying capacity was shown to be less important. Social carrying capacity is very important in the study area with overnight camping shown to be the limiting factor. The individual alpine lake is proposed as the primary analysis unit. Site analysis is the primary method of investigation. Alternatives are proposed for a range of visitor uses. The selected alternative is compared to the management objectives and the site analysis information. Carrying capacities are produced for each lake. The sum of the individual carrying capacities is the proposed total carrying capacity for the Soldier Lakes Basin. Steps needed to implement this carrying capacity are discussed. The site analysis process is dynamic and can be easily expanded or reduced in scope to handle a wide variety of wilderness carrying capacity studies.

INTRODUCTION

The Challis National Forest manages 787,000 acres of the 2.2 million acre Frank Church--River of No Return Wilderness. Within this acreage, there is a large diversity of recreational opportunities, ranging from rafting and kayaking to backpacking, fishing, and hunting. In this vast area, recreation is concentrated primarily in certain areas. The rafting and kayaking on the Middle Fork and main forks of the Salmon River is a good example. The floating season accounts for over 80,000 visitor days recreation on the Challis, mostly confined to the Wild and Scenic River Corridor. With the exception of big game hunting, most of the backcountry recreation is quite site specific.

This report deals with summer backpacking and horsepacking into the high mountain lakes, primarily for fishing and sightseeing. The Frank Church--River of No Return Wilderness differs from nearby wilderness areas, such as the Sawtooth or Bridger, as not having vast areas of continuous high elevational alpine lakes. While these alpine lake areas are smaller than some, they are not less beautiful. The spires and peaks of the Bighorn Crags, for instance, rival the Sawtooths for dramatic scenery. There are several of these high mountain lake areas on the Challis National Forest's portion of the Frank Church--River of No Return Wilderness and more in the remainder of the Wilderness. On the Challis, the high mountain lake area with some of the greatest intensities of use is the Soldier Lakes Basin on the Middle Fork Ranger District. The area contains approximately two dozen alpine lakes, half of which are directly accessible by trail and half which support good fishing populations. The geomorphy of the area is composed of glacial cirque headlands, barren peaks and timbered moraine lands, spectacular scenery common to Central Idaho. The area is compact and easily traversed in a several day backpacking trip. A developed campground, Josephus Lake, serves as the main trailhead and is accessible on a good gravel road from Highway 21 near Stanley, Idaho. The neat, compact nature of this highly used wilderness area, coupled with having most of the problems associated with high mountain lake areas, seemed to make this a good example to use for a study plan.

The management plan for the Idaho Primitive Area (IPA), the document used for interim management of the Frank Church--River of No Return Wilderness until the Wilderness Plan is completed, separated out areas of high mountain lakes as a separate management unit deserving special management attention. Because of the similarities between areas of mountain lakes in the Frank Church--River of No Return Wilderness, this study should be applicable to all these areas in a greater or lesser degree. It is hoped that this study

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will be useful to managers of other wilderness areas that have alpine lakes and the management problems and opportunities associated with them.

THE EXISTING SITUATION

The Soldier Lakes Basin was not included in the original IPA designation. Being on the border of the IPA and part of the same large backcountry area, the area was managed, for the most part, the same as the backcountry in the IPA.

The IPA Management Plan of 1978 made some basic assumptions and management decisions concerning the High Mountain Lakes Management Unit.

BASIC ASSUMPTIONS

1. Recreational use will increase more rapidly in the High Mountain Lake Management Unit than in other portions of the IPA. 2. Backpacker use will increase much more rapidly than horse use. 3. There may be a substantial increase in recreation use if reclassified as Wilderness. 4. Deterioration of the wilderness environment will continue unless management practices are initiated to reverse this trend.

This section of assumptions has been substantiated by direct observations and Forest Service recreational use reporting. Use is quickly increasing in the high mountain lakes area as compared to other areas. Backpacking has greatly increased and is the major type of activity. The wilderness environment has continued to degrade, and since classification as wilderness, backcountry use has greatly increased.

MANAGEMENT DECISIONS

1. Initiate whatever management measures are necessary to prevent further deterioration of the wilderness environment. 2. Enact a variety of restrictions on horse travel and packing. These decisions were site specific. 3. Implement equally to each section (those users in a private capacity and those users outfitting with commercial operators) any controls needed to limit use of heavily used high mountain lake areas. 4. Patrol heavier used areas with Wilderness Rangers and educate both private users and commercial outfitters to the wilderness ethic.

This summary of the management decisions for the High Mountain Lakes Management Unit puts the emphasis on people management and infers that carrying capacities need to be determined to prevent further deterioration. There is a large volume of literature concerning wilderness carrying capacity, most of it very detailed and much of it ambiguous. The time does not exist for the field personnel to make an indepth study of vast tracts of wilderness to arrive at carrying capacities. The complex interaction of social and physical factors of backcountry recreation, as well as the great variation in definitions of wilderness and wilderness experiences, make determining carrying capacities a difficult task. But the need exists for someone at the field level to come up with numbers, whether for the number of horses allowed in a packstring, or the number of people camped at a lake. This paper will investigate the literature of wilderness carrying capacity, and try to apply a summary of these findings on a sample area.

The purpose of the paper is to document the thought process and research findings used to arrive at a sample carrying capacity. Hard number coefficients are not the goals, rather exploring opportunities and using common sense to arrive at a flexible carrying capacity that can be molded and changed as management direction, user attitudes, and the environment change, are the goals. Carrying capacity should not be a static tool. It is a very subjective set of numbers and situations that should be monitored to achieve the desired management direction.

LITERATURE REVIEW

As was previously stated, a large body of literature exists on wilderness carrying capacity. The literature is divided into two main subject headings: (1) ecological research on wilderness carrying capacity, and (2) social research on wilderness carrying capacity (Hendee and others 1977). In any research problem, one needs to decide what data is necessary to collect and what is not. One can quickly become absorbed in data collection for data collection sake. The big question is in defining the problem. In almost all cases, there are capacity problems in both the ecological and social sciences in any one particular wilderness area. Which capacity problem is the limiting factor?

The Wilderness Act of 1964 states . . . "each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have been established as also to preserve its wilderness character . . ." By law, the Forest Service is required to prevent ecological damage, and thus damage by overuse cannot be ignored. The Wilderness Act further states that, "Natural ecological succession will be allowed to operate freely to the extent feasible."

But further provisions create somewhat of a paradox, "Wilderness will be made available for human use to the optimum extent consistent with the maintenance of primitive conditions."

Primitive seems to refer more to the social character of the wilderness than the ecological.

There seems to be no clear cut direction for wilderness management. Wilderness character must be preserved, but wilderness will be made available to human use.

Ecological Literature

Is ecological damage the primary concern in the Soldier Lakes? As shown in research, most damage to vegetation around campsites occurs in the first use season (Heberlein n.d., p.69). Even moderate to low use thereafter will keep the area bare of vegetation with continuing erosion. There are wilderness areas where overuse does lead to severe problems in defoliation, soil compaction, trail destruction, water quality and wildlife impacts, on a large scale, but fortunately, in Idaho, the problem seems less intense. If we are managing for the recreational experience of wilderness and the maintenance of the wilderness environment, this environment needs to be substantiated. Is it the physical environment or the social environment or both? In relatively lightly used wilderness areas, they can be separated.

On field reconnaissance in the Soldier Lakes Basin, the dispersed campsites along the lake seemed to be in poor shape, exhibiting symptoms of overuse: no vegetation, compacted soil, horse damage, fire rings, and litter. In talking with parties of backpackers at almost every lake, the ecological condition of the lakeshore was seldom mentioned as a concern.

The conversations were indirect and did not have a questionnaire format and the results were not mathematically tabulated. Rather, by observation and general conversation, questions on wilderness management were interjected whenever the opportunity arose. By far, the more frequent comment was, "There was too much litter," followed closely by "There are too many people," specifically when they want to camp by a particular lake. When the poor shape of the shoreline was pointed out to them, most agreed there was a concern, but did not give much importance to it, or mistook the statement to mean the large amount of litter around the lakes. In this case, where is the problem? What is the limiting factor? The lake shores were in poor shape and did not approach an area ". . untrammeled by man," but this did not seem to be an important concern or issue. Perhaps the user who demanded a pristine environment has moved out. The only data collected are from the recreationist that is now using the area. There seems to be a gap between the majority of the wilderness users and researchers as to what constitutes ecological damage.

Observations confirmed that resource damage was occurring around the lakeshores, but also led to the feeling that this damage is not a major issue or concern. These ecological impacts then were compared to several impact guideline ratings. Comparing the impacts at Soldier Lakes to Sidney Frissell's campsite condition classes, put most of the backcountry campsites into a condition class 3 and a few in condition class 2.

Taking an average for the area as condition class 3, Frissell's possible management actions were investigated. He recommends modification of current use patterns and intensities to prevent further change, or accepting the condition as normal in areas of high attraction. Upon further investigation with David Cole's "System for Monitoring Impacts on Backcountry Campsites," (Cole 1981), major campsites had overall low summary ratings, an indication that ecological change and damage was not as widespread as first expected.

Dailey's work in the Bridger Wilderness (Dailey 1980), also substantiates the idea that the social carrying capacity is very often more limiting than the physical. He gives an example of a lake that may be physically able to handle six groups, but because of visual and noise sensitivity, can only accommodate two groups and still maintain the social carrying capacity.

Heberlein suggests that the limiting factor in the Grand Canyon may be social carrying capacity and suspects the same for much of backcountry recreation.

Taking the limited public comments into account and the results of comparison of two accepted systems for monitoring and judging impacts on backcountry sites, the decision was made, for this study, to concentrate on the social aspects of wilderness carrying capacity. The more this conclusion was explored, the more viable it seemed for this area. There definitely exist wilderness areas where the ecological components in determining carrying capacity are very important. In the majority of the Frank Church--River of No Return Wilderness and other low-use wilderness areas, the social component tends to rank higher in importance with the users than the ecological component, and in fact, seems to be the limiting factor for carrying capacity determination.

In comparing the situation in the Soldier Lakes Basin to the "model of acceptable variation in wilderness experience," it seems that the limit of acceptable change on the human contact side of the graph has been exceeded, and that the limit of acceptable change in resources quality has not been reached. This is a difficult subjective decision to make, but a necessary one if time and effort are to be saved. The definition of limits of acceptable change can be very complex and detailed. Use only that level of detail that is necessary. General observations, user interviews, current management

direction, and sample plots should be considered. If the ecological carrying capacity has been exceeded or looks to be exceeded, the site analysis method needs to be expanded. Both the sketch map and the site form can be expanded to include relevant resource items. Alternatives would be formulated from the resource data contained in the site analysis.

Social Literature

If the definition proposed by Lime for recreation carrying capacity is accepted, "The amount and character of use an area can sustain over a specified time period without causing unacceptable change to the physical environment or to the experience of the user," it is necessary to define within limits what these amounts and character of uses are. These cannot be constructed until it is understood what constitutes unacceptable change to the experience of the user. A significant amount of wilderness user data has been collected by researchers trying to define unacceptable change. There has been a surprising amount of agreement among researchers concerning the interpretation of this data.

Some basic visitor preferences have been interpreted from this data. The number of encounters and the size of group has been shown to be very important in most studies. Small groups were preferred over large groups, low or no contacts were preferred, but this still does not define what constitutes unacceptable change (Hendee and others 1977, p. 176-177). In doing a field exercise, the man on-the-ground cannot be expected to collect data and investigate all types and amounts of visitor contacts. Once again, the investigation needs to be narrowed, that common thread or limiting factor needs to be found. What is the limiting factor of social carrying capacity in the Soldier Lakes Basin? Visitor behavior and patterns of use need to be closely looked at before one can concentrate on what primarily limits use. As was previously discussed, the area is heavily used for short to medium length backpacking trips to see and fish the many mountain lakes. Virtually all camping is located at or near the lakes. There is one main trailhead, but the area is accessible by trail from three other secondary trails. Trails or trailhead contacts could be a limiting factor, but direct observation and limited user interviews did not show this as a concern. The lakes are quite close to one another and time spent hiking to the lake does not constitute a major portion of the time spent on a typical trip. Research tends to back up this hypothesis, as showing trail contacts as being not as important as campsite contacts and visitors being somewhat more tolerant of numbers or contacts on the trails (Hendee and others 1977, p. 177). While there is some day hiking in the area, the majority of use is overnight. The observations and data collected suggested that backcountry campsites at the alpine lakes were the limiting factor for social carrying capacity. What support for this assumption existed in the literature? Dailey used campsite solitude as the primary determinant in assessing supply capability in the Bridger Wilderness (Dailey 1980, p. 22). Hendee (n.d.) and Stankey (n.d.) both suggested in separate reports that relative solitude at the campsite may be the most important item in determining overnight capacity.

Stankey (n.d.) states that carrying capacity is not only a function of use levels, and type of use, but also the location of encounters and evidence of depreciative behavior.

At this point in the investigation, the decision was made to concentrate on overnight camping as the primary determinant of carrying capacity. There was some indication from the literature that trail encounters could be a limiting factor, but the preliminary investigation did not back up this hypothesis. In the three days spent in the area, encounters at the lakes far outnumbered those on the trail. None of the people interviewed noted that trail congestion away from the trailhead was a problem. The relatively short trail system greatly reduced trail contacts as the amount of time spent hiking on the main trail was much less than time spent at camp, fishing, or hiking the secondary trails. The exceptions to this were the several lakes located right next to the main trail. This seems to be a separate problem of trail location and was not deemed serious enough to adjust carrying capacity.

The decision was made that trail encounters should affect carrying capacity in the Soldier Lakes Basin, but should not be the primary determinant. Carrying capacity figures from overnight camping would be adjusted to reflect trail capacity, if required.

The study has narrowed from the entire spectrum of ecological and social carrying capacity to studying campsites at 20 relatively small alpine lakes.

STUDY UNITS

What is the method used in looking at these campsites and what is the unit of investigation? Past studies have used the backcountry campsite as the investigating unit, especially those primarily concerned with ecological carrying capacity. Dailey (1980) has created an excellent site identification form for the Bridger Wilderness. Cole (1981) has created another excellent one. Identifying and analyzing sites is very important in carrying capacity, but it is a very detailed approach. Most small lakes in Soldier Lakes Basin have several, up to a dozen, areas where people had camped, well above any capacity figures proposed in the literature.

The decision was made to concentrate on the individual alpine lakes and immediate surroundings. There were several reasons for making the lake and lakeshore the primary analysis unit: (1) it was easily identified, both to the manager and the user by a common name and a specific location; (2) it proved a much more manageable number of units; 20 lakes instead of a hundred campsites; (3) it eliminated inconsistencies of comparing different types of campsites; (4) it provides a permanent benchmark for future monitoring; (5) it corresponds directly to related data collections such as fisheries and water quality, and land form analysis; and (6) there is a basis for lakeshore carrying capacity in the wilderness literature.

Schomaker and Brown found that in the Spanish Peaks Primitive Area in Montana, 90 percent of all sites in use had views of a lake, or a lake and a stream (Hendee and others 1977). In the Three Sisters Wilderness in Oregon, campsite concentrations were intense near popular lakes, some seventy sites near a cluster of three heavily used lakes, with only very few sites in use elsewhere in the wilderness (Hendee and others 1977, p. 345).

The main attractions in these high mountain wilderness areas are clearly the alpine lakes. It seems that analyzing these lakes would be the sensible time saving approach. In working from the general to the specific, it is the large analysis unit that supports the campsite, yet campsite inventory remains the usual method. While using the lakes as the primary inventory unit is a departure from accepted wilderness planning, it is still based on the social conditions of overnight camping.

SITE ANALYSIS METHOD

Site analysis is based on the most readily available form of data collection/observation. Site analysis can be general or specific or anywhere in between. The number and type of individual elements in a site analysis vary by the site, the project and the person doing the site analysis. Certain elements occur in most site analyses, whether for an urban park or a wilderness campsite. Site analysis can be conveniently split between ecological elements and social elements, a direct relationship to carrying capacity.

A site analysis of a mountain lake could include:

Ecological Elements.--Form--shape of lake, shoreline, basin. Vegetation--cover, type, density, timber, ground cover. Slope, sun, wind, etc.

Social Elements.--Views--on-site and off-site. Sound. Evidence of man--campsites, fire rings, sanitation impacts, etc. Access--circulation. Location--pattern of use.

There are two parts of the site analysis: a sketch map and a written form. The sketch maps show the shape of the lake, the circulation patterns, the on- and off-site impacts that cannot be accurately portrayed on a written form. The written form gives that information that is difficult to show or describe on a map. Forms also are easy to compare with each other, while maps often are not. Both sketch map and form work well with each other, each adding to the information of the other.

The site analysis form is a combination of elements from Dailey's "Bridger Wilderness Site Identification Form" and Cole's, "Systems for Monitoring Impacts on Backcountry Campsites," and social information that was added from the information gathered for this paper.

DISCUSSION

There is a strong tendency to make recommendations on carrying capacity at the site analysis stage. The site analysis should be considered an information gathering tool and not a design tool. Jotting down ideas, impressions and feelings should be part of the site analysis, but hard decisions on capacity should not be made at this time. The reason for deferring decisions is to avoid being tied down too early in the design process. In this case, there are 20 separate site analyses in the total analysis. There was a tendency, in this case, to design a carrying capacity for each lake without looking at the larger pattern of carrying capacity.

The hypotheses is that the carrying capacity of the Soldier Lakes Basin is the sum of the carrying capacity of 20 alpine lakes. But a social carrying capacity relates to a certain user and his expectations, not necessarily those of the investigator. The questions then arise:

Which users are we planning for? The ones that now use the area? The ones that have been displaced? Or are we trying to accommodate a spectrum of users? It quickly becomes apparent that there is a range of alternatives in managing carrying capacity in the Soldier Lakes Basin. The individual lake is still the primary analysis unit, but the Soldier Lakes Basin remains the management unit. Whatever decisions are made on the management of the total lake basin will filter down to each individual lake. This is where the site analysis for each lake fits in--how to best accommodate the carrying capacity alternative that is selected.

Hard numbers of capacity will be generated at each lake analysis unit, reflecting the carrying capacity ideology selected for the entire lake basin.

ALTERNATIVES

A range of alternatives exists for any wilderness carrying capacity problem, whether for an

entire wilderness or one heavily used lake. In this case, alternatives that dealt with the management of the entire Soldier Lakes Basin were proposed.

1. The area would be managed for pristine or near-pristine wilderness conditions. The opportunity for solitude should exist for most users. Contacts would be minimum on the trails, with no other contacts at lake campsites. Overall capacity would be low, reflecting a maximum of one party per lake and in cases, no overnight camping allowed at lakes closely bordering one another. The wilderness user that has been displaced would have access to solitude at mountain lakes. Ecological damage at campsites would be closely monitored, repaired and management controls would be explicit concerning the maintenance of wilderness conditions.

2. The area would be managed commensurate with the approximate current use level or slightly less. Capacity would be determined by the opportunity for relative solitude at overnight campsites across the entire lake basin. Solitude would not be assured, rather the appearance of solitude would be maintained by determining a carrying capacity at each lake dependent on the potential for each lake to offer solitude. Some lakes, by virtue of form, size and vegetation, can offer a degree of solitude for several parties. Capacity would be designed around the needs of the current user. A degree of ecological damage at campsites would be accepted as permissable, as long as it does not reach the state of seriously impairing wilderness quality and can be maintained at a somewhat stable level. Monitoring would be necessary and guidelines would be managed for. No lake would be managed at a level above its social carrying capacity.

3. The area would be managed at a level commensurate with the approximate current use level or slightly less. Carrying capacity would be the result of zoning groups or individual lakes. Some lakes may be managed for a carrying capacity higher than what is socially acceptable, while others would be maintained in a somewhat pristine condition. A variety of use levels would be maintained for a variety of users. Overall carrying capacity would not exceed that of Alternative 2. Some lakes would be managed to show little or no ecological damage, similar to Alternative 1. While at other lakes, ecological damage may surpass the socially acceptable levels of Alternative 2. Monitoring and mitigation would be an integral part of management.

4. The area would be managed at a use level higher than at present. Use would be permitted to rise until all lakes were at ecological carrying capacity. Social carrying capacity would be met or exceeded at all lakes. Zoning may or may not be an integral part of this alternative, as management prefers. No lake would exceed ecological carrying capacity. Monitoring and mitigation would again be necessary.

5. No action. Let use stabilize without controls or restrictions. Monitor damage and collect use information.

DISCUSSION OF ALTERNATIVES

Alternative 1 is not considered viable at this time. Present use would be reduced considerably and a number of current users would be displaced. There are no data or observations that support the idea that users that demand solitude would be attracted to the area with these restrictions. Further study on the supply and demand of pristine wilderness area is needed.

Alternative 5 is not considered realistic. Existing problems would not be solved. A lowered quality of wilderness experience for the present user will probably result.

Alternative 4 represents a significant change in management in the Frank Church--River of No Return Wilderness. Use levels on the Middle Fork have traditionally been determined on social carrying capacity. This alternative does not take into account the needs of the present user that is concerned about social encounters. There exists a strong demand for wilderness recreation in the area, but for what user group? Quality is still desired by the users contacted in this study. Increasing capacities, while not increasing supply, would not satisfy current demand, but rather create an area that displaces the current user in favor of those who tolerate a high rate of social encounters.

The search for a selected alternative has narrowed to a choice between Alternatives 2 and 3. Both alternatives plan for approximately the same amount of use, the difference being how that use is rationed. Both alternatives provide for the current wilderness user. Alternative 2 is based solely on social levels or zones.

With only limited user observation and interviews, it is difficult to determine a user group composition. As in all planning, there is a high degree of subjectivity and sensitivity. In this case, there is a question of scale. Subdividing an area into zones of use requires a certain amount of area as a minimum area for a wilderness. Size alone is not the only factor in determining scale. Form and structure also apply. In this case, topography is extremely important. An isolated lake in a steep cirque basin, though relatively small in area, could be extremely isolated by topography and poor access.

Relative comparisons are still important. The Soldier Lakes encompass approximately 7,000 acres. Any splitting of this area into zones would require quite small zones. Wilderness

implies a sense of space, especially in the pristine zone. Dailey, in his studies on the Bridger Wilderness, proposed size criteria for zones of use, ranging from 2,500 acres to 5,000 acres. This recreation opportunity spectrum has similar size criteria for its primitive and semi-primitive classifications.

Perhaps the biggest drawback to creating zones of management in this small area is the land itself. Virtually all the lakes lie in one glacial trough, quite close to one another and all serviced mainly from one trail and trailhead. This compact area seems to lend itself to one management area. For this study, Alternative 2 is the recommended alternative. As previously mentioned, carrying capacity should be a dynamic, changing process. The site analysis data that have been collected can be used if another alternative is selected at a later time.

For the purpose of this paper, Alternative 2 will be followed through the analysis stage. The first step is to create the management objectives that each site analysis will be compared to. Alternative 2 states that no lake would have use surpassing its social carrying capacity and that the appearance of solitude would be maintained. With this direction and the information in the individual site analysis, objectives can be proposed:

1. Sounds of human activity not audible from campsite to campsite.

2. Details of activity not visible from campsite to campsite. Details could be defined as activity within a foreground area, where textures are easily seen, usually confined to less than 1/4 mile.

3. User expectations--studies have shown that expectations of seeing other visitors in the wilderness vary with location. People expect to see other people at a popular trailhead or at a popular, close lake. As one progresses farther into the wilderness, his expectations are generally to see fewer, or no, other people. Several factors greatly influence the illusion of solitude, such as vegetation and topography, both masking sights and sounds effectively. These simple criteria of sights, sounds, and generalizations can be compared to each site analysis. A carrying capacity can be proposed for each lake. When proposing individual carrying capacities, it is important to document subjective decisions, as they may change as time or management changes. Carrying capacities for three lakes are proposed:

<u>Lost Lake</u>: <u>Discussion</u>.--A long lake with a rugged, irregular shoreline. Dense vegetation and rock on the west shore. Poor circulation around lake, no trail access or trail around lake. Thick spruce and waterfall on southeast corner. Camps 1 and 3 not visible from each other. Normal sounds not audible across length of lake. Orienteering necessary to reach lake; very dense and steep access. Expectations of seeing others run very low.

<u>Recommendations</u>.--Manage for two camping sites at each end of lake, two small backpacking parties, 14 people.

<u>Helldiver Lake</u>: <u>Discussion</u>.--Good trail access, first lake from main trailhead. Marsh and talus restricts most camping to north end of lake. Very heavily used. Vegetation dense, but sights and sounds reach all campsites. Expectations of seeing others are high.

<u>Recommendation</u>.--Manage lake for campsites for one large party or three small backpacking parties. No room for horses. Reroute trail away from shore of lake.

<u>Cutthroat Lake</u>: <u>Discussion</u>.--The last lake in the Soldier Lakes Basin from the main trailhead. A small round lake in thin timber. Use is currently low. Sights and sounds travel easily across the lake from any point on the shoreline. Several good camping spots. A nice waterfall creates a pleasant spot. Expectations of seeing others are low.

<u>Recommendation</u>.--Manage for one campsite, either horse or backpack party. The results of this process create a total carrying capacity for the basin. A chart is useful for displaying carrying capacity by lake:

Lake	No. of parties Small size (1-4) Backpack only	No. of parties Large size (5+) Backpack or horse
1. Lost	2	
2. Helldiver	3	
3. Cutthroat		1
4. 1st. Lieutenant	2	
5. Colonel		1
6. General		1
7. Major		1
8. Sergeant	1	
9. Staff Sergeant	1	
10. 2nd Lieutenant	1	
11. PFC	2	
12. Iris Lake #1	2	
13. Iris Lake #2	1	
14. Iris Lake #3	1	
15. Unnamed Lake #1	1	
16. Unnamed Lake #2	2	
17. Unnamed Lake #3	1	
18. Unnamed Lake #4	2	
19. Unnamed Lake #5		2
20. Unnamed Lake #6	1	
Total Capacity	23	6

In each case, party number was less than the number of available campsites, usually by a factor of two or three. This has distinct advantages:

1. It allows freedom of choice. Campers have a choice of several camps at any single lake,

and can locate themselves in relation to other campers.

2. Management is less complicated; no reserving specific sites, rather reserving areas; less inventory and monitoring; and less overall paperwork.

Lakes 12 to 20 did not have a site analysis completed for them. A tentative carrying capacity was proposed using aerial photographs to complete the study.

The proposed carrying capacity is for 29 individual wilderness campsites, the majority (23) being managed for small backpacking parties, with only six suitable for horses or a large backpacking group.

Two items need to be investigated before implementing a carrying capacity:

1. Does this capacity surpass any other carrying capacities that were overlooked in the process? In this case, are 29 parties on the trails creating an unacceptable level of trail encounters? A quick schematic sketch of where people are concentrated will show potential trouble spots. The Soldier Lakes have a very dispersed camping pattern that has no area, except the trailhead, that has high use concentration. With 29 parties on the trail, the first 2-mile section of trail could have high encounter levels, but number of encounters would quickly lower as people disperse. Trail capacity, as previously proposed, should not be a problem.

2. Use should be monitored for at least a season prior to implementation of the carrying capacity to see how a limit of 29 parties will affect current use. Small changes in overall carrying capacity can occur at this stage.

Stankey and Baden (1977) have prepared an excellent work dealing just with the problem of rationing wilderness use. They list five alternatives in wilderness rationing.

1. Rationing by reservation
2. Rationing by lottery
3. Rationing on a first-come, first-serve basis
4. Rationing by price
5. Rationing by merit

In this rather complete discussion, they proposed evaluation criteria that affect both the wilderness user and the administrator. Management implications and guidelines are discussed.

WORK STILL TO BE DONE

1. Complete site analysis on lakes 12-20 with field review.

2. Revise carrying capacity if necessary.

3. Propose a rationing system.

4. Set up a monitoring program.

   a) Social carrying capacity criteria:

      1) Determine benchmark level.

      2) Propose a threshold level of social standards.

      3) Devise a sampling method to collect use data and comments.

   b) Ecological carrying capacity criteria:

      1) Determine benchmark level.

      2) Propose a threshold level of ecological standards.

      3) Revise a sampling method to monitor ecological change.

      4) Develop a method to revise the Soldier Lakes carrying capacity plan to reflect ecological concerns if environmental threshold levels are reached.

5. Solicit public input on the selected alternative, proposed carrying capacity and rationing method. This step should be ongoing throughout the process.

6. Schedule an annual plan review to change carrying capacity if necessary.

7. Program and schedule the needed budget and personnel requirements.

REFERENCES

Behan, R.W., 1976. Rationing Wilderness Use: An Example from the Grand Canyon. Western Wildlands, Spring 1976. 23-26 pp.

Bratton, Susan P., Nickler, Matthew G., and James H. Graves, 1979. Trail Erosion Patterns in Great Smokey Mountains National Park. Environmental Management, Vol. 3 No. 5.

Bury, Richard L. and C. Ben Fisle l. Controlling Wilderness Recreation: What Managers Think and Do. Journal of Soil and Water Conservation.

Cole, David N., 1981. Managing Ecological Impacts at Wilderness Campsites: An Evaluation of Techniques. Journal of Forestry, Feb., 1981. 86-89 pp.

Cole, David N., 1981. Systems for Monitoring Impacts at Backcountry Campsites: A Review with Recommendations. USDA-Forest Service Res. Pap. INT-May 1981, Review Draft.

Dailey, Dennis R., 1980. Bridger Wilderness Visitor Management Planning. USDA-Forest Service unpublished.

Frissel, Sidney S. Jr., and Ronald P. Duncan, 1985. Campsite Preference and Deterioration. Journal of Forestry, April 1975, 265-260 pp.

Frissel, Sidney S., 1978. Judging Recreation Impacts on Wilderness Campsites. Journal of Forestry, August 1978, 481-483 pp.

Godin, Victor B. and Raymond E. Leonard, 1979. Management Problems in Designated Wilderness Areas. Journal of Soil and Water Conservation. May-June 1979, 141-143 pp.

Griest, David A., 1975 Risle Zoning. Journal of Forestry, Nov. 1975, 711-714 pp., 431-445 pp.

Heberlein, Thomas A. Density, Crowding and Satisfaction: Sociological Studies for Determining Carry Capacities. (n.d.).

Helgath, Sheila F., 1975. Trail Deterioration in the Selway-Bitterroot Wilderness. USDA-Forest Service Research Note INT-93. 14 p.

Hendee, John C., Catton, William R. Jr., Marlow, Larry D. and C. Frank Brockman, 1968. Wilderness Users in the Pacific Northwest - Their Characteristics, Values and Management Preferences. USDA - Forest Service Research Paper, PNW-61.

Hendee, John C., Stankey, George H. and Robert C. Lucas, 1977. Wilderness Management, USDA - Forest Service, Miscellaneous Publication No. 1365.

Knudson, Douglas M. and Elizabeth B. Curry. Campers Perceptions of Site Deterioration and Crowding. Journal of Forestry, Feb. 1981. 92-94 pp.

Leonard, R.E. and others 1980. Management Guidelines for Monitoring Use on Backcountry Trails. USDA - Forest Service Research Note NE-286. 19 p. (n.d.).

Lime, David W. Principles of Recreational Carrying Capacity.

Lucas, Robert C., 1964. The Recreational Capacity of the Quetico-Superior Area. USDA - Forest Service Res. Pap. LS-15. Sept. 1964.

Lucas, Robert C., 1964. Wilderness Perception and Use: The Examples of the Boundary Waters Canoe Area. Natural Resources Journal, Jan. 1964. 394-411 pp.

Lucas, Robert C., 1980. Use Patterns and Visitor Characteristics, Attitudes and Preferences in Nine Wildernesses and Other Roadless Areas. USDA - Forest Service Research Paper INT-253, July 1980.

Lucas, Robert C. and George H. Stankey, 1973. A Selected Bibliography of Wilderness Literature. Symposium on Management Implications of Wilderness Research, RWV-1903, Pub. #17.

Lucas, Robert C. and George H. Stankey. Social Carrying Capacity for Backcountry Recreation. Intermountain Forest & Range Experiment Station, Ogden, UT. 23 p.

Rupe, Mary Lynn, et., 1979. Hikers Views of Backcountry Management. University of Vermont Research Report, SNR-RM6, April 1979.

Shechter, Mordechar and Robert C. Lucas, 1978. Simulation of Recreational Use for Parkland Wilderness Management, Johns Hopkins University Press, Baltimore.

Shelby, Bo, 1980. Crowding Models for Backcountry Recreation. Land Economics, Vol. 56, No. 1: Feb. 1980.

Stankey, George H. and John Baden, 1977. Rationing Wilderness Use: Methods, Problems and Guidelines. USDA - Forest Service Res. Pap. INT-192, July 1977.

Stankey, George H. and David W. Lime, 1973. Recreational Carrying Capacity: An Annotated Bibliography. USDA - Forest Service General Technical Report INT-3.

Stankey, George H., (n.d.). Visitor Perception of Wilderness Recreational Carrying Capacity. USDA - Forest Service Res. Pap. INT-142.

USDA Forest Service, 1978. Management Plan for the Idaho Primitive Area. Intermountain Region.

USDA Forest Service, 1976. Wilderness Management Plan for the Glacier Peak Wilderness. Pacific Northwest Region, April, 1976.

VanWagtendonk, Jan W., and James M. Benedict, 1980. Travel Time Variation on Backcountry Trails. Journal of Leisure Research, Vol. 12, 94-104 pp.

VanWagtendonk, Jan W., and James A. Benedict, 1980. Wilderness Permit Compliance and Validity. Journal of Forestry, July 1980, 399-401 pp.

Wagar, J. Alan, 1974. Recreational Carrying Capacity Reconsidered. Journal of Forestry. May 1974, 274-278 pp.

Wagar, J. Alan, 1964. The Carrying Capacity of Wildlands for Recreation. Forest Science Monograph, 7-1964.

Wilkenson, Paul F., 1978. Environmental Impact of Outdoor Recreation and Tourism: A Bibliography. Public Administration Series: Bibliography P-57, Aug. 1978.

CARRYING CAPACITY DETERMINATION FOR WHITEWATER RIVERS IN WEST VIRGINIA

Franklin E. Boteler

ABSTRACT: Following case studies attempting to delineate a process for setting carrying capacity for whitewater rivers, emphasis was found to be placed on statutory empowering legislation and sociopolitical functioning of the land management agency. As a result, support is found for Stankey and McCool's (1984) model rather than Shelby and Heberlein's (1984).

INTRODUCTION

The role of research efforts in setting carrying capacities for recreational use has been the subject of much debate. Recently an issue of Leisure Sciences was devoted to the topic. In that issue, two contrasting models for carrying capacity determination were articulated.

Shelby and Heberlein (1984) suggest that carrying capacity determination requires a descriptive component and an evaluative component. "The descriptive component documents the observable workings of the recreation system, while the evaluative component integrates value judgements into the capacity determination" (Shelby and Heberlein 1984, p. 434). They go on to emphasize the importance of social carrying capacity and list the following three conditions that are necessary to establish it:

1. There must be a known relationship between use level or other management parameters and experience parameters.
2. There must be agreement among relevant groups about the type of recreation experience to be provided.
3. There must be agreement among relevant groups about appropriate levels of the experience parameters.

In contrast, Stankey and McCool (1984) outline a carrying capacity planning framework that focuses on the management of conditions. Emphasis in their model is placed on managers who must "identify the location, type, and level of change considered appropriate and acceptable in an area and the actions consistent with protecting an area from changes in excess of those judged acceptable" (Stankey and McCool 1984, p. 460). They list the following nine steps in their Limits of Acceptable Change (LAC) planning process:

1. Identify area issues and concerns.
2. Define and describe opportunity classes.
3. Select indicators of resource and social conditions.
4. Inventory existing resource and social conditions.
5. Specify standards for resource and social indicators for each opportunity class.
6. Identify alternative opportunity class allocations reflecting area issues and concerns and existing resource and social conditions.
7. Identify management actions for each alternative.
8. Evaluate and select a preferred alternative.
9. Implement actions and monitor conditions.

This paper illustrates how, in attempts to solve a deadlock among private and state governmental groups, the Stankey and McCool model proved useful. Six years of efforts to set carrying capacities for three heavily used whitewater rivers in West Virginia revealed carrying capacity determination to be a contentious task mediated through a political process and dependent on statutory empowering legislation for public agencies. Stankey and McCool's model was found to be applicable to the West Virginia situation since it emphasizes management of conditions, not cooperation or compromise among users, as the Shelby and Heberlein model does.

EVOLUTION OF CONCERNS WITH OVERUSE

During the last two decades, whitewater use of West Virginia's rivers has dramatically increased. In the early 1960's only a few "pioneers" braved the violent waters; currently over 200,000 people run three rivers within the State annually. Whitewater use on four other rivers within West Virginia is developing rapidly.

Initially, only individuals with highly specialized skills could run the most violent rivers in the State. Narrow channels, flashy watersheds, remote access, and continuous Class IV and VI rapids created conditions that only a few commercial outfitters could navigate.

However, as these companies expanded they trained greater numbers of guides to meet the growing whitewater demand. To the chagrin of the original company owners, after some of their guides attained the prerequisite whitewater skills and knowledge of company operations, they ventured out to create their own companies. This

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process continued until 1981 when the Department of Natural Resources (DNR) put a moratorium on licensing of new commercial outfitters. By that time 50 companies had been licensed to run rivers within the State.

The increase of newer, smaller, often more aggressive companies broke down informal agreements among the larger companies to hold use levels down. It became obvious that the rivers would become severely overcrowded before the competitive marketplace would function to control use levels.

Responding to this situation, in the late 1970's, some of the larger companies joined into an informal association. Motivated by a desire to protect their businesses, they were concerned with possible compromises in the quality of their customers' experiences. Obviously, the availability of a high-quality experience within a relatively prisine environment is essential to the healthy functioning of their companies.

RESPONSE TO CONCERN WITH OVERUSE

Following an initial review of the failure of efforts to voluntarily limit use numbers, some of the company owners decided to attempt legislation that would set carrying capacities without unduly interfering with their operations. They generated financial resources to support a lobbyist on a commission basis. As a result, within 2 years the West Virginia Legislature passed a law that mandated carrying capacities for whitewater zones within the State.

The wording of the law reflected concern with overuse of rivers resulting in significant ecological impacts, compromise in the quality of experience for whitewater users, and concerns for users' safety (Boteler 1983, 1985). The law directed appointment of a whitewater citizen advisory board mandated to work with the DNR in setting carrying capacities. After 5 years, the board's composition has boiled down to three whitewater company owners, one company representative, one commissioner, and one DNR official. It obviously reflects an emphasis on commercial whitewater use by giving commercial company owners a majority vote with little representation of private users' interests.

ATTEMPT TO SET OBJECTIVES

In spite of its domination by industry, the board found it impossible to agree on the type of recreation experience to be provided--a prerequisite for application of the Shelby and Heberlein model. Different rafting companies had carved their "niches" in the business by marketing different types of experiences. Some had cultivated a clientele interested in highly social experiences using large rafts and opportunities to observe and be with others. Other companies had cultivated a clientele interested in small-group solitude using small rafts and attempting to keep away from the larger crowds. Still others were interested in using motorized rafts on one of the rivers.

Because many of the companies had large investments in marketing a particular kind of experience, there was very little interest in compromise. Indeed, many of the company owners were suspicious of one another's motives when appeals to compromise were made.

Further complicating matters, the DNR was not in a position to mandate desired experiential objectives for whitewater users. Since its operating funds are allocated by the State Legislature and administrative positions are not protected by civil service classification, the DNR attempts to avoid alienating important constituent groups--particularly ones with effective lobbying efforts. Sociopolitical origins and functioning of the agency pattern it toward a reactionary role to constituent pressures rather than an affirmative role in recreation resource management.

THE PROCESS OF SETTING CARRYING CAPACITY

To circumvent the stalemate resulting from its inability to set experiential parameters, the board commissioned studies of whitewater use on three of the State's rivers. Although the stated purpose was to gather needed information relevant to carrying capacity determination, the DNR hoped that an objective academic effort could result in carrying capacity figures.

The initial study conducted on the Cheat River (Boteler 1983) provided a significant amount of information relevant to carrying capacity, but could not suggest use limits. Based on the Shelby and Heberlein model, the study report concluded that there must be agreement among the relevant groups about the type of recreation experience provided and there must be agreement among the relevant groups about appropriate experience parameters. The board responded that those kinds of agreements were impossible. Indeed, that was labeled by one commercial outfitter as unrealistic, wishful thinking.

The second study (Roggenbuck and Bange 1983), performed on the New River, attempted to define users' desired experience on the river by surveying commercially outfitted customers. Rafting company owners responded to this by banding together to oppose the results of the study and constracting with a consultant to rebut it when the final results were presented. Furthermore, some of the company owners hinted at bringing suit on the basis of unfair restraint of trade if carrying capacities were established on the basis of the study.

The third study (Boteler 1985), conducted on the Gauley River, had the advantage of hindsight. Since it had become clear there could be no agreement on experiential parameters, the study attempted to suggest a carrying capacity that

was acceptable within the politicized decision-making process. As a result, the key parameter in setting carrying capacity became a concern with user safety (Boteler 1984).

Through working with representatives from the State attorney general's office, it became clear that the principal statutory mandate supporting DNR's role in setting carrying capacity was found in protecting user safety. Emphasis on user safety as a carrying capacity parameter was also advantageous because it provided a politically acceptable criterion that all involved parties could accept as a reason to limit use numbers.

Safety was investigated by employing a combination of participant observation, unobtrusive observation, and structured interviews with rafting company guides and owners (Boteler 1983, 1985). From this it was established that safety becomes a proportionately greater concern when backups (queues) occur at rapids. When queues occur, users begin to act in unsafe ways such as holding paddle battles, jumping out of rafts, or taking off personal flotation devices. Therefore the criterion for setting use limits was to minimize queues.

THE UTILITY OF CONTRASTING CARRYING CAPACITY MODELS

By necessarily responding to the sociopolitical decision-making environment, carrying capacity determination paralleled a course charted by Stankey and McCool's (1984) model. Issues and concerns were identified early on by legislation and the advisory board. The indicator of relevant social conditions was the relationship of queues to user safety. The specified standard became minimizing queues. The prerequisite agreement between relevant groups called for in the Shelby and Heberlein model was impossible to reach. The utility of Stankey and McCool's model was found in its ability to include relevant legal and political factors in the decision-making process.

FUTURE WORK

Carrying capacity determination for whitewater rivers in West Virginia has been patterned by the predominant sociopolitical forces acting on the decision-making structure. One limitation of this approach is that it has resulted in the establishment of use limits that are higher than some relevant groups might want. Use limits have been set to minimize queues with little attention on experiential desires of the various user groups.

Rather than providing a management strategy that allows variety in recreation opportunities, the use of minimizing queues as the criterion for setting carrying capacity may result in only one type of experience for river enthusiasts. In short, responding to necessities of the sociopolitical decision-making environment has resulted in a defacto, common-denominator recreational experience rather than the variety of experience enlightened management would desire.

REFERENCES

Boteler, Franklin E. A study of carrying capacity and safety concerns associated with commercial rafting industry use of Cheat River Canyon, West Virginia. Morgantown, WV: West Virginia University, Division of Forestry; 1983. 303 p.

Boteler, Franklin E. The safety component in riparian carrying capacity: a Cheat River case study. In: Proceedings of the third conference on social research in National Parks and Wildlands; Gatlinburg, TN: U.S. Department of Interior, National Park Service; [In press].

Boteler, Franklin E. A study of carrying capacity and safety concerns associated with commercial rafting industry use of the Gauley River, West Virginia. Morgantown, WV: West Virginia University, Division of Forestry; 1985. 405 p.

Roggenbuck, Joseph; Bange, Steven P. An assessment of the float-trip carrying capacity of the New River Gorge National River. Blacksburg, VA: Virginia Polytechnic Institute and State University, Department of Forestry; 1983. 202 p.

Shelby, Bo; Heberlein, Thomas A. A conceptual framework for carrying capacity determination. Leisure Sciences. 6:433-451; 1984.

Stankey, George H.; McCool, Stephen F. Carrying capacity in recreational settings: evolution, appraisal, and application. Leisure Sciences. 6:453-473; 1984.

DESIGNING A LOW-COST MONITORING SYSTEM FOR DESOLATION WILDERNESS, CALIFORNIA

Kenneth C. Chilman

ABSTRACT: Monitoring is becoming recognized as important to recreational carrying capacity strategies. How are monitoring systems developed? The monitoring system designed for Desolation Wilderness draws on experience with monitoring in other situations. A short set of questions for recreation quality monitoring was utilized under field conditions to demonstrate feasiblity.

INTRODUCTION

Monitoring is integral to recreation management and an important component of recreational carrying capacity models (Chilman 1981; Washburne 1982; Stankey and others 1985). But monitoring is not often done in the field.

In Desolation Wilderness near Lake Tahoe in California, for example, use limits were recommended in the mid-1970's. A wilderness management plan limiting use to 2,100 visitors per day was adopted by the U.S. Forest Service in 1978, with the stipulation that a "continuing program" be conducted to evaluate and adjust capacity (USDA 1978). However, a Regional Office inspection report in 1982 pointed out that Desolation Wilderness managers "have not monitored the use to see whether the quotas are accomplishing their purposes." We were then asked to help the managers design a monitoring system for Desolation.

It has been our experience that managers hesitate to implement monitoring programs and cite as their reasons: lack of funding and personnel, uncertainty about monitoring methods, difficulty of data analysis, and uncertainty about how the results will be used. Therefore, when we were contacted by Desolation Wilderness managers to design a monitoring program, our goal was to develop a system that could be used annually to gather and analyze social and physical site information with very little or no increases in administrative budgets. Specifically, we wanted to develop monitoring procedures that could be included in the present wilderness rangers' duties, and that would take less than ten percent of their work time. If managers are to implement monitoring, they will need to see examples of existing systems to understand just what is involved and how it can be used.

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METHODS

Discussion of monitoring needs with the Desolation managers focused on evaluating visitor's perceptions of crowding, the major concern when the permit quotas were initiated. (The managers had mapped site impact areas and had a system for evaluating them). The immediate concerns became lack of funding for data collection and design of methods to fit this constraint. Would it even be possible to consider data collection and analysis with the severe funding constraints existing on the management unit?

The researcher's previous experience with other wilderness management units indicated that wilderness rangers' duties included visitor contacts (for checking permit compliance, providing information, etc.). A set of questions relating to perceptions of crowding could be asked to a sample of visitors during these contacts. The set of questions would need to be kept short to minimize visit interference and managers' time to collect and analyze data.

A set of ten questions had been developed and utilized in previous monitoring research (Chilman and Kao 1982). Our interest in monitoring research began in 1973 at Land Between The Lakes, a Tennessee Valley Authority area in western Kentucky and Tennessee. The first designated off-road vehicle riding area on federal lands was established there in that year, and a monitoring program was initiated (McEwen 1978). The managers there had knowledge of available physical and biological monitoring methods, but methods were needed for social monitoring of visitors' perceptions of their recreation experiences.

At about the same time, we began a system of social monitoring measurements at Ozark National Scenic Riverways, a National Park Service area in south central Missouri. Concerns about rapidly increasing numbers of canoeists on the 140 miles of riverways led to a series of studies of visitor numbers and perceptions of conditions (Marnell and others 1978). Essentially, our monitoring questions focused on canoeists' perceptions of crowding, and were done initially in 1973 and repeated in 1977, 1979 and 1983 (Chilman and others 1985). We used three kinds of questions relating to crowding: perceptions of numbers of other visitors expected, perceptions of numbers of other visitors desired, and problems caused by other visitors (Appendix A). We obtained relative indications of perceptions of crowding for the overall area and by various sections for planning purposes, and indications of problems

for immediate management attention. In addition, questions about reasons for visitors' choice of the area and perceptions of changes occurring were asked.

It was decided to utilize this short set of questions for Desolation monitoring. First, however, we wanted to examine the rangers' work routines in the field to learn whether monitoring data collection would interfere with other work responsibilities and what sample size could be obtained within these routines. Accordingly, we scheduled time to accompany Desolation Wilderness rangers during their patrol activities during summer 1983, and to accompany them and demonstrate visitor monitoring data collection techniques in 1984.

These monitoring system design activities were done within the research design of participant observation, negative case analysis as described by Kidder (1981). Participant observers begin with a preliminary hypothesis, then look for data that would disconfirm the hypothesis. When a single negative case is found, the participant observer revises the hypothesis in light of that case and applies it again in another case. This process takes the place of statistical analysis, and represents inductive instead of deductive research.

The Desolation monitoring case analysis thus followed from the two previous monitoring studies at Land Between the Lakes and Ozark Riverways. The hypotheses were: (1) that the monitoring system could be designed to fit within constraints of available personnel and funding, i.e., could be accomplished involving no more than ten percent of existing work routines, and (2) that the short set of questions developed in the previous monitoring studies could be used without further modification. The ten percent in the first hypothesis was considered acceptable in discussions with management personnel.

The particular form of participant observation used in these studies is that of the researcher participating as a member of the management staff of the field unit, i.e., as a social science information specialist. This role is facilitated by the researcher's nine years of work experience as a wildland recreation manager. A part of the research design is to focus on situations where carrying capacity issues (1) are identified by field level managers (2) who want to actively participate in finding useful approaches to the issues. The managers' active involvement provides research insights as to how they understand and communicate the nature of the carrying capacity issue, and whether they see the research approach as feasible and useful.

RESULTS

The first question to be addressed was: Is it even possible to consider monitoring, given the constraints on funding and personnel existing at Desolation? Several days were spent on-site during the summer of 1983, discussing needs for monitoring, Desolation Wilderness management as it existed, and monitoring methods. A two-day trip was made to the U.S. Forest Service Regional Office in San Francisco to discuss the Desolation situation and the study approach to be used. Then the investigator traveled with two of the wilderness rangers during four work-days, to observe the nature of their management units and duties performed.

Cleanup of campsites and checks on wilderness permits were primary work efforts. Management units appeared to be covered systematically and thoroughly by the rangers. Most of the visitors using the area were contacted; an estimated twenty-five percent of the rangers' work time was spent in visitor contacts. A brief summary report of their activities was prepared by the rangers at the end of the work week. Thus it appeared that a few short interviews and a tabulation of results could be incorporated into the schedule of work activities.

Information collection methods were tested by the investigator during a second trip to Desolation in 1984. The researcher brought the ten question interview form used in previous studies, in a format to be used and carried in a small field notebook (Appendix A). Questions were placed on the left-hand facing page, and responses recorded on the facing right-handed pages. The investigator spent time with each of the three wilderness rangers during work time on their individual management units, demonstrating interviewing techniques.

Interviews took less than five minutes. If each ranger did three interviews on their work schedule of four ten-hour days, they would have twelve short interviews to tabulate at the end of their work-week, as part of their weekly written report. The weekly interview summaries could then be added by months, and by major management subunits (Haas and Nachtman 1979). This could total 400 interviews for Desolation for the summer. Total interviewing and tabulation time should be less than two hours per week for each ranger, approximately five percent of their work time. This was considered by management personnel as very acceptable, and meets the conditions of the first hypothesis.

The second hypothesis was that the short set of questions could be used as developed in previous cases, without need for modification at Desolation. The questions were well received by interviewees, partly because of the short format but also because of the visitors' obvious enjoyment of the Desolation area, and their willingness to talk about their visits. But this hypothesis involves consideration of how the responses will be used.

The purpose of the interviews was to document visitors' perceptions of existing conditions, and changes that have occurred or are occurring. In part, there is overlap with the inventory (of existing resource and social conditions) step of recreation planning models, e.g., Stankey and others (1985) Limits of Acceptable Change process. But more immediately, it should serve as

the basis of weekly discussions between rangers and their supervisors on changes occurring and management actions to be undertaken (Haas and Nachtman 1979).

Six interviews were conducted to train the rangers. They generally indicated the area was less crowded than they had expected from previous reports, although some of the reports were not recent. These six were too few to establish baseline levels of visitors' perception of crowding, but they did indicate other insights for management.

Four of the six respondents offered comments on the good condition and cleanliness of the area: two had requests for trail signs or trail maintenance. While these are only indicator responses, they do provide a measure of management efforts (that use conditions are favorable and clean-up and contact work well done) and suggestions for improvement (trail sign needed, better trail marking in one location).

The questions were thus judged to be useful in their present form, without modifications required by the particular Desolation situation. The questions, although few in number, do provide documentation of visitors' perceptions of conditions and they also serve to identify visitors' perceptions of important aspects of the site visit and changes that may be occurring in conditions, and how conditions may be improved. As such they provide specific and structured insights for management use in both short-range and long-range planning.

Beyond the general findings that simple monitoring measurements are available and feasible, we also discussed with the managers the two other barriers to implementing monitoring systems as noted above: difficulty of data analysis and uncertainty about how the results will be used. For data analysis, we suggested use of the analysis/summary methodology developed by Haas and Nachtman (1979). That methodology includes the following steps: "one, a file was developed for each sampling unit in which the units respective field data was stored. Two, a summary form was developed for the data collection instruments. Three, the data were summarized every week during office hours as opposed to one general summary at the end of the field season. Four, the employee's supervisor reviewed each summary (particularly the first few) and provided constructive feedback. Five, the weekly summarization provided the basis for preparing the overall summary report which was drafted in the last few days of the seasonal's employment. Six, a debriefing "rap" session was scheduled with all the seasonal employees and appropriate District staff in order to verbally exchange information, opinions, and recommendations for management and further data collection efforts."

We also discussed the possibility of doing a revision of the Desolation Wilderness Management Plan in two or three years, based on the monitoring results. The revision could be facilitated by using recently outlined planning procedures (Stankey and others 1985).

DISCUSSION

Monitoring is a topic of current interest in recreation management. Yet few examples of monitoring systems exist. What have we learned from our efforts to develop a monitoring system for Desolation Wilderness?

Although monitoring methods exist and appear to be feasible at Desolation, there are still other barriers to implementing monitoring systems. First, there are competing demands on the entire Lake Tahoe Basin Management Unit recreation system. Desolation Wilderness management is only one relatively small part of the complex recreation management responsibilities in Tahoe Basin. While monitoring may receive attention in a particular inspection report, those concerns are soon replaced by more immediate concerns, especially in times of reduced budgets and personnel.

Second, there have been several changes in ranger and supervisory personnel. There have been three changes in ranger staff and four changes in supervisory personnel since 1983. With these changes, the focus has been mostly on keeping the wilderness management system operating rather then thinking about adding new responsibilities, such as monitoring.

Third, there are the requirements of Office of Management and Budget (OMB) clearance for the interview questions. While this has been done by other federal agencies for short field interviews, e.g., National Park Service (Hornback 1980), it still adds another time-consuming complication to the process of instituting monitoring.

Will these barriers be overcome? Is the monitoring system worth the effort for Desolation Wilderness? From several discussions with the managers, it appears they will move ahead to implement monitoring. Two things happened in these discussions. First, we had to change our rationale for monitoring from abstract research jargon of "better quality recreation" and "redo the wilderness plan" to concepts that related more directly: "document the good job being done" and "make Desolation better known as a demonstration of good management". Second, we had to think of monitoring as a short-term "what's happening now" concept rather than trying to sell the more complicated, long-range "redo the wilderness plan".

Monitoring, like other aspects of recreation management, turns out to be more complicated to implement than it first appears. Monitoring systems are needed in wildland recreation management, as in other wildland resource systems, to provide current and continuing information for management decisions. Studies of other case situations, similar to Desolation, are needed to learn more about developing and implementing monitoring systems.

REFERENCES

Chilman, Kenneth C.; Marnell, Leo F.; Foster, David. Putting river research to work: a carrying capacity strategy. In: Lime, David W.; Riele, Donald R., tech. coord. Some recent products of river recreation research. General Technical Report NC-63. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981: 56-61.

Chilman, Kenneth C; Kao, Jem Y. Quality of outdoor recreation: A short set of questions used for field level resource management. In: Brademas, D. James, compiler. Abstracts from the 1982 Symposium on Leisure Research: proceedings; 1982 October 24-27; Louisville, KY. Alexandria VA: National Recreation and Parks Association; 1982. 19 p.

Chilman, Kenneth C.; Foster, David; Everson, Alan. Using visitor perceptions in river use planning 1972-1985. In: First North American Riparian Conference: proceedings; 1985 April 16-18; Tucson, Arizona. University of Arizona; 1985 (in press).

Haas, Glenn E.; Nachtman, Steven C. A more efficient and effective utilization of a U.S. Forest Service seasonal employee. Ft. Collins, CO: Department of Recreation Resources, Colorado State University; 1979. 56 p. Research report.

Hornback, Kenneth E. The trend of measuring public use of the national parks. In: Proceedings: 1980 National Outdoor Recreation Trends Symposium. General Technical Report NE-57. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeast Forest Experiment Station; 1980: 233-241.

Kidder, Louise H. Research methods in social relations. 4th ed. New York: Holt, Rhinehart and Winston; 1981. 483 p.

Marnell, Leo F.; Foster, David P.; Chilman, Kenneth C. River recreation research at Ozark National Scenic Riverways. Van Buren, Missouri: National Park Service; 1978. 139 p. Research report.

McEwen, Douglas N. Turkey Bay Off-Road Vehicle Area at Land Between the Lakes: an example of new opportunities for managers and riders. Carbondale, IL: Department of Recreation, Southern Illinois University; 1978. 28 p. Research report.

Stankey, George H.; Cole, David N.; Lucas, Robert C.; Peterson, Margaret E.; Frissell, Sidney S. The Limits of Acceptable Change (LAC) system for wilderness planning. Gen. Tech. Report INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

U.S. Department of Agriculture, Forest Service. Desolation Wilderness management plan. South Lake Tahoe, CA: Lake Tahoe Basin Management Unit; 1978. 54 p.

Washburne, Randel F. Wilderness recreational carrying capacity: are numbers necessary? Journal of Forestry 80: 726-728; 1982.

APPENDIX A

QUESTIONS ASKED--DESOLATION SURVEY--1984

The following questions were contained on a page in a small field notebook.

VISITOR MONITORING - DESOLATION 1984

I. <u>Visitor Characteristics</u>
   1. How many times have you visited Desolation Wilderness?
      1a. What was the first year you visited?
   2. What is the nature of this visit, i.e., day hike, destination camp, etc.?
      2a. No. of days on this visit?

II. <u>Recreation setting comparison</u>
   3. Do you visit other wilderness areas like Desolation? Which ones?
      3a. Why did you choose Desolation today rather than others you mentioned above?
   4. Have you visited other parts of Desolation? Which ones?
      4a. Why choose this part today?

III. <u>Changes Occurring in the Setting</u>
   5. Have you noticed any changes in Desolation since your first visit?

IV. <u>Perceptions of Crowding</u>
   6. Have you seen more people in Desolation than you expected? Less? About right?
   7. Have you seen more people than desired? Less? About right?
   8. Have other people been a problem? In what way?
   9. Where do you live?

V. <u>Additional Comments</u>
   10. Any additional comments for the F.S.?

A WILDERNESS TRAVEL SIMULATION MODEL

WITH GRAPHIC PRESENTATION OF TRAIL DATA

Allen L. Rowell

ABSTRACT: This paper presents a software system for plotting visitor concentration and encounter data related to wilderness travel simulation on maps drawn by a personal computer. A number of benefits for wilderness managers are derived from this system including accessibility, interactive use, a holistic view, efficient evaluation of results, and validation of the simulation model. A method for simultaneous presentation of different aspects of trail networks is described.

INTRODUCTION

Wilderness managers are working to improve the standard of the wilderness experience. With the current high use in many wildernesses and the likelihood of increased use, managers must take actions that will preserve "opportunities for solitude" as stipulated in The Wilderness Act (PL 88-577, section 2(c)). Some management actions such as building new trails, limiting access, and designating campsites are designed to alter visitor use patterns, and thus increase recreational carrying capacity and visitor satisfaction. To select the best alternative, managers need to evaluate the effects of possible management actions. However, wildernesses are large, complex systems that defy direct, systematic observation. Furthermore, manager intuition is often not adequate for assessing complex recreation use patterns (Manning and Potter 1982). The job of the simulation modeler, therefore is to develop tools that simplify the comparison of effects of management actions.

Simulation models are useful tools for experimenting with large scale traffic systems such as wilderness trails. Using models, data which would be too expensive to gather can be generated. Computer graphics aid simulation modeling and analysis and encourage analysts and managers to effectively use simulation (Miner 1982). Computer graphics allow users to visualize elements of large, complex systems. In wilderness systems, for example, traffic congestion, encounter levels, intersections, and spatial relationships among trail segments can be plotted on maps. These maps can be used by wilderness managers to get an overview of recreation use patterns and encounters.

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The maps are also useful to students and laypersons interested in understanding wilderness use problems.

A wilderness travel simulation model and associated computer graphics for a personal computer are described in the following sections.

THE WILDERNESS TRAVEL SIMULATION MODEL (WTSM)

A wilderness travel simulation model was developed in 1975 by Resources for the Future, Inc., in cooperation with the U.S. Forest Service (Smith and Krutilla 1976), and updated by Shechter and Lucas in 1978. These versions are difficult for decision-makers to use, however, because one needs to know how to run large computers, the input is difficult to prepare, and the results are presented in large and complex tables.

I have written a travel simulation model for a personal computer that overcomes these difficulties. The user does not need to know much about computers to run it, data are easy to enter, and the results are depicted graphically.

My simulation model is more likely than previous versions to affect decisions because it involves the decision-maker more directly in the simulation in two ways. First, because it runs on a personal computer, it is accessible to more people than versions on large computers, and it can be used interactively. Second, because it displays input and output data graphically, model definition, operation, and results are clearer to decision-makers.

Given present costs, personal computers are accessible or can be obtained by managers in most agencies. And unlike earlier versions when one simulation might cost $75 - 100, a simulation on a personal computer is essentially free after the initial investment in equipment. Costs, therefore, do not limit the number of simulations that can be run. In addition, the easy-to-use program allows the screen to be used interactively to update the data base, review summary statistics, or draw maps.

Benefits Of Graphics

Through the graphic display of input and output data, decision-makers benefit by obtaining a holistic view, efficient evaluation of results, and validation of the model.

Holistic view.--The transfer of large amounts of complex information can be greatly facilitated by the use of graphics. By representing data graphically on a map, not only are the results displayed, but geographical relationships are also made clear. Unlike a table, a map reveals important information about relationships in a simulation model. For example, in a wilderness model trails which access the periphery or feature attractions of an area are immediately identifiable within the whole trail network. Moreover, a map constructs a constant reference shape that permits immediate and easy comparisons among simulations. For example, a sequence of displays through time enables the decision-maker to visualize complex interactions among trail users. Seeing the big picture helps the decision-maker formulate further studies and actions.

Efficiency.--A graphic display allows the decision-maker to learn essential results of the analysis almost immediately and to evaluate strategies in a more organized and efficient manner. The graphic presentation removes much of the drudgery of analysis and enhances productivity.

Validation.--Graphic display of the simulation as it proceeds increases the confidence of the decision-maker in the model's ability to accurately represent the system. Once the simulation model has been proven accurate, the graphics display helps detect errors in input data and checks that the simulation algorithms are working properly.

The literature contains a limited number of references to application of computer graphics to travel simulation and its benefits. The most notable subjects are railroad networks (Kornharser and others 1983) and urban highway distribution (Koren 1983). Many of the benefits outlined above were delineated by studies of these types of systems. Development of original graphics for the present project is aimed at achieving these benefits.

Implementation

Versions of the Smith-Krutilla model have been used to simulate use in the Spanish Peaks Wilderness Area (Smith and Krutilla 1976), the Desolation Wilderness Area (Shechter and Lucas 1978), and a 63-mile section of the Appalachian trail (Manning and Potter 1982).

The Smith-Krutilla model is written in General Purpose Simulation System (GPSS) computer language. Due to the non-availability of GPSS compilers and programmers a version of the Smith-Krutilla model was coded in FORTRAN by Douglas Eza at the University of Georgia, School of Forest Resources (Eza 1980). The present version was coded in Pascal to allow execution on a personal computer.

The program requires an NCI (Network Consulting Inc.) version of the UCSD p-system (version C.1 or later) with Turtlegraphics. The program is running on an IBM Personal Computer with 128 kilobytes of memory, two 360 kilobyte diskette drives, and an IBM Color Graphics Card. Graphic output is via a color monitor. For a hard copy of tabular output an optional printer and printer control card must be added to this system.

THE DATA BASE (MODEL INPUT)

Pascal is particularly adaptable to simulation modeling. With its powerful data types such as pointers and records, a complete characteristics record is easily implemented and maintained. In addition, the lists necessary in the simulation, when implemented as linked-lists, can be easily searched and updated. This dynamic data structure allocates memory only for the number of groups, routes, and segments defined for a particular simulation rather than for large arrays of predetermined size as in previous versions. This efficient use of memory is a prerequisite for running a complex model on a small computer.

Two sets of data are required to run the model: one describes the trail system and the other describes travelers. These input variables are essentially the same as those required by previous versions of the WTSM (table 1). However, in my version, these variables are entered differently and the data base is structured differently.

Entering Data

Input variables are typed into tables displayed on the computer's monitor (table 2). The need for coding into a computer format has been significantly reduced. When all values have been entered in a particular table, the user is given the opportunity to change any of the values. When the user is satisfied that the values are correct, he continues to the next table and the data are stored on diskette. After all tables have been filled, the user may selectively view and edit any of the input tables. This ability to update the input data is important in two respects. First, the task of typing in the rather large amount of input data is made bearable. Second, and more

Table 1.--A list of input data tables

USE INFORMATION
1. Weekly distribution by day
2. Hourly distribution by day type
3. Trailhead distribution by day type
4. Group type distribution by trailhead
5. Size distribution by group type
6. Speed modifiers for each group type and size
7. Route distribution by period for trailhead type 1
8. Route distribution by period for trailhead type 2
9. Route distribution by period for trailhead type 3

TRAIL INFORMATION
10. Route segment sequences
11. Segment transit times and link coordinates

Table 2.--An example of an input data table as it would appear on the monitor

Size Distribution by Group Type			
Group type	Sml	Size Med	Lrg
1	0.30	0.50	0.20
2	0.00	1.00	0.00

R(ienput table, E(dit table, C(ontinue →

importantly, various scenarios can be tested simply by changing the values of selected variables.

The input procedures are designed to be easy to use and self-checking. The program provides the user with many convenient options and prompts the user with clear instructions at each step of the process. Also, the program accepts only appropriate values for certain variables and asks that data be re-entered when unreasonable results occur. For example, the proportions across the rows or columns of the tables must sum to one before the user is allowed to continue to the next table.

Structure

Each party of travellers is defined as a group. The traveller data base is constructed as a list of groups. A record is created for each group defined. The characteristics of the group (type, size, arrival time, position, speed) are stored in the group's record. Pointers link all records together into a list. This list can then be searched to find, for example, groups who are on the same trail segment.

The core of the system is the trail data base. It contains coordinates for the entire wilderness trail network. The data base has an heirarchical structure and contains records for routes, segments, and links of coordinates. Each segment record is composed of a list of links. Each link record contains a set of (x,y) coordinates that defines a point along the segment. A second level of data structure is used to group segments together into routes (fig. 1). A logical sequence of trail segments and campsites defines a route of travel (note that a campsite is defined as a special type of trail segment).

The trail network can be manually digitized from existing maps at any scale desired. Since the trail network may be redefined to test alternative scenarios, the data base must be easily updated. A set of editing procedures takes care of digitizing new trails and changing existing trails.

DRAWING MAPS (MODEL OUTPUT)

The system contains procedures for drawing trail maps and for representing visitor use data on these maps. Map data are of two kinds: point data and interval data. Point data are traffic congestion, intersections, and trail heads and are represented by symbols drawn at the appropriate position along the trail. Interval data are traffic volumes and encounter levels and are represented by either trail width or color for the entire trail segment.

Drawing Point Data

The maps are drawn with a minimum of background information--only the boundary is included to make orientation easier. Trails are drawn by plotting the coordinates associated with all segment links. Links divide each trail segment into intervals (fig. 2). The length of these intervals may be chosen to conveniently describe the path of the segment, but the resulting display of interval data is more visually meaningful if the links in a particular segment are approximately the same length. Drawing all segments, including campsites and the boundary, constitutes the base map.

Each group is plotted on the map as a small figure. Usually these figures do not represent the exact location of the group because on high density segments the figures overlap and make the map unreadable. Instead, all groups which are located on a link are drawn as a set of figures uniformly distributed along the link. All groups are represented by the same shape figure, but different types of groups can be represented by different color figures. Note that congestion is interval data but that it is treated as point data and depicted at the approximate location of individual groups.

By refreshing the display for every ten minutes of simulated time (one "tick" of the simulation's

Segment List	Link List			
Seg. 1	(x,y) ,	(x,y) ,	(x,y) ,	...
Seg. 2	(x,y) ,	(x,y) ,	(x,y) ,	...
Seg. 3	(x,y) ,	(x,y) ,	...	
etc.	...			
Route List	**Segment Sequences**			
Rt. 1	Seg. 1,	Seg. 2,	Seg. 3,	...
Rt. 2	Seg. 1,	Seg. 4,	Seg. 5,	...
Rt. 3	Seg. 7,	Seg. 8,	...	
etc.	...			

Figure 1.--Each set of consecutive coordinates defines a link. connecting all the coordinates in a link list defines a segment. A sequence of segments describes each route used in the simulation.

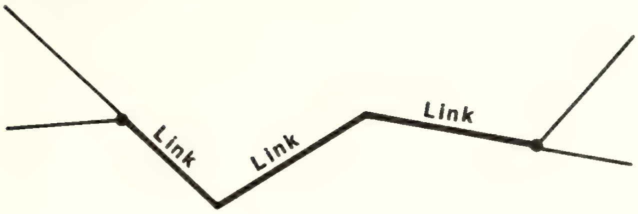

Figure 2.--Detail from a trail map. A segment between two trail junctions described by three links.

clock), a rough animation of the traffic flow is achieved. This allows the decision-maker to see the evolving pattern of traffic congestion--a novel opportunity. Optionally, the display can be refreshed only on the hour or at the end of each simulated day. This allows the user to speed up the program's run time, but with a corresponding loss of animation.

Drawing Interval Data

For visualizing interval data, each segment of the trail is represented as a pair of parallel lines. The values of the interval data are represented by varying the width of lines or the color of a single line. Two types of interval data are represented--traffic volume and encounters. The greater the traffic volume--the number of groups on each trail segment during some period--the greater the distance between parallel lines drawn to represent that segment (fig. 3). The number of encounters occurring for each trail segment during some period is represented by varying the color of a single line. The encounter data are divided into discrete categories and each category is represented by a color chosen by the decision-maker.

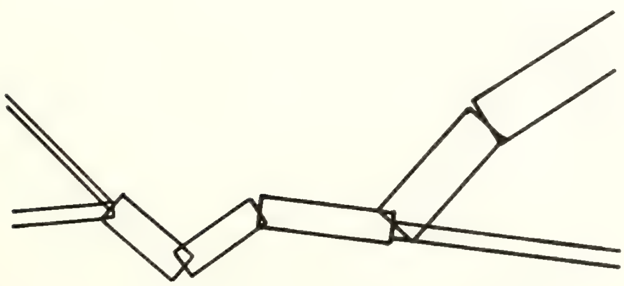

Figure 3.--Detail from a trail map. The greater the traffic volume or number of encounters occurring on a segment, the greater the width of the rectangle drawn to represent that segment.

Limitations

The resulting maps are not meant to replace detailed numerical output but rather to make its analysis more efficient. Computer graphics can present much information that can be used to classify congestion and encounters. For example, data, time, place, type of group involved, and type of encounter (camping or hiking) can be represented by a single map. How much information a particular map actually conveys will depend on how it is constructed.

When constructing cartographics to represent comprehensive information, two questions must be answered: First, what is at a given place? And second, where is a given characteristic? The first question is answered by superimposing point data to construct a base map. This map, and all maps mentioned, are meant to give an overview. Since the trails are digitized, it is not possible to show point data in detail. The location of groups relative to curves, intersections, etc., is only generalized on these maps.

The second question is answered by transcribing an ordered characteristic such as the encounter level onto the base map. Of course, the encounter level could simply be represented by a number value written on appropriate segments of the map. But this would produce a "reading map" which conveys information on an elementary level not very different from a table. Conversely, a "seeing map" allows one to immediately perceive the distribution of a characteristic defined by both geographical and numerical proximity.

As characteristics are superimposed, the resulting representation quickly degenerates into an elementary reading map. A series of maps is necessary in order to answer the second question. "Thus, it is not possible with complex information to represent several characteristics in a comprehensive way on a single map while simultaneously providing a visual answer to our two types of question. ... When both types of question are pertinent, as is generally the case, there is only one satisfactory solution: making several maps" (Bertin 1981). That is we must make a superimposition map for answering the first question, and make one map per characteristic for answering the second question.

Scheme

Using these criteria, I devised the following scheme for representing different aspects of trail system use. Congestion data is continuously displayed as the number of groups per link. If congestion is considered as point data, then superimposing this information with the other point data constitutes another form of the base map. Accordingly, only one additional characteristic should be displayed at a time to insure a visually meaningful display. One way to classify traffic congestion is by the type of travelers or groups involved (day hiker versus backpacker, backpacker versus horse-packer, etc.). Simple differentiation will suffice to identify the groups of a particular

type. Any pattern in the behavior of that group type, different from the overall congestion pattern, will be obvious when viewing the simulation.

Color is used to differentiate between groups of different types. The range of colors available in this system is limited (three plus the base color: black). Since colors are qualitative, and not particularly useful for representing quantitative information, at most two colors (in addition to the base color) are used to differentiate a characteristic. Therefore, the available set of colors is adequate.

There are a number of other characteristics which may be displayed. The encounter level per hour, the encounter level per day, or the traffic volume per day can be superimposed on the original base map. The encounter level per simulated hour is indicated by two possible changes in color. For example, a base map is drawn in black, then, for each segment, when over five encounters have occurred in an hour the segment is drawn in yellow; over ten encounters and the segment is drawn in red. The encounter level per hour can be superimposed over the evolving congestion pattern. This map still conveys visual information but risks degenerating into a "reading map."

Two other mappings are available. At the end of each simulated day, the viewer may optionally display the traffic volume or number of encounters per segment for that day. The symbology for these themes has already been described. These mappings are scaled relative to the data being displayed. For example, the largest number of encounters per segment on a particular day defines the top of the scale for that day's map. This scale is divided into four equal intervals plus the interval zero-to-one. All segments are drawn as rectangles of one of five widths depending on which of these five categories it falls into. An appropriately numbered scale is drawn on each map.

NEXT STEP

A system has been developed that, with some additional work, could provide wilderness area managers with an important new tool for understanding wilderness use problems.

The feasibility of using a personal computer to graphically present congestion and encounter data has been demonstrated. It seems clear that computer graphics can help wilderness area managers interpret and validate the operation of the simulation model.

The utility of applying this system to the study of wilderness travel patterns needs further study. To assess the usefulness of viewing the evolving patterns of simulated wilderness travel will require application of this system to a real world situation. Perhaps applying the system to an area studied using previous versions of the WTSM would be most enlightening. The results of any such application will be more significant if the involvement of wilderness-oriented, computer-illiterate users is stressed. Further study should also include as an objective some demonstration of confidence in the ability of the model to produce realistic results and in the ability of the computer graphics to accurately represent these results.

REFERENCES

Bertin, Jacques. Graphics and graphic information-processing. Transl. by: Berg, William J.; Scott, Paul. Berlin; New York: de Gruyter; 1981. 274 p.

Eza, Douglas. Description of a wilderness simulation model. 1980. Unpublished draft supplied to author by D. Eza.

Koren, Hans; Holbaek-Hanssen E.; Tjugen, O. H.; Wiborg, T. Computer graphic presentation of road data. In: Hagen P. J. W. ten ed. Eurographics '83: Proceedings of a symposium; 1983 August 31 - September 2; University of Zagreb, Faculty of Electrical Engineering, Zagreb, Yugoslavia: Elsevier Science Publishers B. V.; 1983: 275-285.

Kornharser, A. L.; Hornung, M.; Hazony, Y.; Lutin, J. M. The Princeton Railroad Network Model: application of computer graphics in the analysis of a changing railroad industry. Teicholz, E. and Berry, B. J. L. Computer graphics and environmental planning. Englewood Cliffs, NJ: Prentice Hall, Inc.; 1983: 241-244.

Manning, Robert E.; Potter, Fletcher I. Wilderness encounters of the third kind: the computer hikes the Appalachian Trail. In: Boteler, Franklin E. ed. Wilderness Psychology Group: Proceedings of a conference; 1982 July 8-9; Morgantown, WV. West Virginia University, Division of Forestry; 1982.

Miner, R. J.; Sabuda, J. D.; Wortman, D. Graphics and simulation: tools and application. In: Highland, H. J.; Chao, Y. W.; Madrogal, O. S., ed. Winter simulation conference: Proceedings of the symposium; 1982 December 6-8; San Diego, CA: Vol. 1, 161-178.

Schneider, J. B. Mapping congestion patterns on urban highway networks. Teicholz, E. and Berry, B. J. L. Computer graphics and environmental planning. Englewood Cliffs, NJ: Prentice Hall, Inc.; 1983: 202-223.

Shechter, M.; Lucas, R. C. Simulation of recreational use for park and wilderness management. Baltimore: Johns Hopkins University Press for Resources for the Future, Inc.; 1978.

Smith, V. K.; Krutilla, J. K. Structure and properties of a wilderness travel simulator. Baltimore: Johns Hopkins University Press for Resources for the Future, Inc.; 1976.

U.S. Laws, Statutes, etc.; Public Law 88-577. "The Wilderness Act." Act of September 4, 1964.

HIKERS' OPINIONS ABOUT FEES FOR BACKCOUNTRY RECREATION

Burnham H. Martin

ABSTRACT: Fee-paying and non-fee-paying hikers in the White Mountains of New Hampshire were questioned to learn their opinions about user fees for backcountry recreation. About half felt the government should continue to fully fund backcountry services although only about one-third felt fees would have a negative effect on their experience. Hikers favored returning fee revenues locally. Voluntary contributions were favored over other systems. Differences between fee-paying and non-fee-paying hikers were ambiguous.

INTRODUCTION

Federal and State land-managing agencies are currently considering user fees for backcountry recreation. There are at least two reasons for their interest: overall budget cuts have led to reduced growth or even decline in backcountry recreation budgets, and the present administration's philosophy is that users of government services should contribute to their cost. As this paper is written, Federal and State laws have been drafted to authorize fees for backcountry recreation. There is economic research available for evaluating the user fee issue and legislative proposals. Comparatively few studies have focused on hikers' opinions about fees.

A number of studies have been concerned with the attitudes and experiences of visitors paying fees at developed recreation areas. For example, 1 percent of the visitors to New Hampshire campgrounds surveyed by LaPage (1968) were opposed to fees. McCurdy (1970) found that 61 percent of the visitors to a wildlife refuge in Louisiana were in favor of a new fee that had provoked strong public disapproval prior to being emplaced. New and improved facilities were cited as one factor for improved acceptance. Manning and Baker (1981) interviewed visitors to a city park before and after institution of a fee. About 60 percent of the visitors approved of a user fee both before and after it was put into effect. The $1 car entrance fee did not reduce numbers of users, but it did change the type of use in a positive way. Visitors appreciated improvements made possible by fee generated revenue. Economics Research Associates (1976) surveyed 800 households throughout the United States and found that for every category of respondent, a majority favored user fees for recreation. These studies show that a majority of participants and the general public accept fees for developed recreation. It is questionable whether the results can be extrapolated to backcountry recreation.

There are a few studies that pertain directly to fees for backcountry recreation. In 1977, Backpacker printed a questionnaire about user fees in response to a U.S. Department of the Interior Fish and Wildlife Sevice (FWS) proposal to charge an excise tax on backpacking equipment. More than 450 readers filled out the questionnaire or wrote a letter stating their opinions. Ninety-seven percent were against the excise tax on equipment, while 62 percent favored a tax if the revenue were returned to backcountry management. Ninety-one percent felt that income from a fee should be used for activities related to hiking, such as trail maintenance and land acquisition (Kemsley 1978).

A study of hikers' attitudes about backcountry management, including user fees, was conducted on Camel's Hump, Vermont by Rupe and others (1979). Hikers there favored a number of other rationing techniques over fees. However, two-thirds of the respondents were supportive of a fee that would be used for trail maintenance. The study questions focused on management of Camel's Hump and may have limited applicability to backcountry visitors' reactions to a broad-based user fee.

Godin (1984) conducted a study that focused on the attitudes of hikers in the White Mountains of New Hampshire toward fees. A questionnaire was administered to 374 hikers, most of whom were using backcountry facilities for which a fee was charged. It asked for opinions about how backcountry recreation should be provided and feelings about the best fee collecting technique. The results showed that 63 percent of the respondents favored fees as opposed to increased taxation or allowing services to decline. Respondents displayed mixed feelings about various means of collecting fees.

The National Parks and Conservation Association (NPCA) printed a questionnaire in their member magazine in response to another FWS excise tax proposal in 1985. This questionnaire drew 263 responses. About two-thirds of the respondents

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were opposed to an excise tax and 51 percent were willing to pay for trail use. About one-third of the respondents reported they would reduce their trail use if fees were charged (NPCA 1985).

There are privately held land areas in the East where backcountry visitors are charged a user fee, for instance, Grandfather Mountain, North Carolina (Johnson 1984) and the North Maine Woods (Cowperthwaite 1984). In some areas, nonprofit organizations maintain facilities and charge for their use; this is the case at some shelters run by the Green Mountain Club in Vermont (Van Meter 1984). Managers of those areas reported that visitors were generally willing to pay fees. Users were particularly satisfied when they perceived that their fees are helping maintain or improve an area.

The studies of backcountry visitors' reactions to user fees noted above have limitations that may affect applicability of their results. The Backpacker and NPCA survey respondents were self-selected. The Rupe study focused on management of one Vermont State Park and the fee questions related only to that State Park. Generalizations about the acceptability of fees to hikers in other areas based on these results may be inaccurate.

Both Godin's study and the experiences of managers of fee systems for backcountry recreation demonstrated a willingness to pay fees for backcountry use. However, all of these experiences reflected the opinions of hikers who were paying fees. Godin surveyed mainly users of Appalachian Mountain Club (AMC) fee facilities. It is possible that those backcountry visitors who dislike fees stay away from those areas and facilities where fees are charged. In this case, surveys of fee-paying hikers would yield inaccurate results as to the general acceptability of user fees.

This study compared the attitudes of White Mountain hikers who were paying fees during their trip with those who were not paying fees. The specific objectives of the project were:

1. To determine hikers' attitudes toward a broad-based (statewide or nationwide) fee system.

2. To determine hikers' attitudes toward specific characteristics of a fee system.

3. To identify the differences between the opinions of fee-paying and non-fee-paying hikers.

METHODS

A questionnaire designed to meet the objectives of the study was pretested in June 1984 and subsequently modified slightly. The introduction to the questionnaire noted that both State and Federal governments are feeling budget pressures and considering user fees as one means of providing adequate backcountry recreation services. The first series of questions asked respondents to choose one of six means of providing backcountry recreation: reduce backcountry services; increase taxation; charge user fees; increase volunteerism; combine user fees and increased volunteerism; and reallocate government budgets.

The second section included multiple-choice questions about hikers' experiences with fees, who should provide backcountry services, what amounts might be appropriate to charge, and where fee income should be credited. The third section asked users to indicate their feelings about seven fee systems: licenses, windshield stickers, general entrance fees, separate fees for each service or facility, search and rescue insurance, an excise tax on equipment, and voluntary contributions. The possible responses were: favor, neutral, or opposed. The final section asked demographic questions and also whether the respondent had ever personally volunteered for or contributed money to backcountry management. These questions were either multiple-choice or open-ended.

Hikers in the White Mountains can be divided into four categories: day hikers; backpackers using free overnight facilities or camping beside the trail; backpackers using fee sites; and hut users. Hut users stay in one of eight AMC huts; they are provided a bunk and two meals for $25.75 per night (1984 price). There also are six overnight backpacking sites that have heavy enough use that they are staffed by a caretaker. Facilities consist of a combination of tent platforms and shelters. The fee for these sites was $3 in 1984. There are about 50 free cabins and lean-tos available. In most of the National Forest, dispersed camping is legal. There are camping restrictions in heavily used areas.

The questionnaire was administered to hikers from July 12 through September 9, 1984. Questionnaires were distributed at 21 stations that were either overnight sites or trailheads and along the trail between stations to hikers 16 years old or older. A convenience sampling pattern was used with stations visited selectively to ensure adequate representation of backpackers. A total of 584 usable questionnaires were collected. The sample included 197 day hikers, 105 nonpaying backpackers, 115 fee-paying backpackers, and 167 hut users.

The assumption is made that this is a representative sample of White Mountain hikers. Comparison of hiker demographics in this study with those noted in earlier studies supports this contention (AMC Hut System 1980; AMC Research Department 1983; Godin 1984; Graefe and others 1984).

For analysis, the questionnaires were coded to indicate whether they represented fee-paying or non-fee-paying hikers. All other responses were cross tabulated against these hiker category codes. Additional cross tabulations were run when there was a prospect of interesting results. Chi-square tests for independence of distributions were run when the response frequency allowed.

RESULTS AND DISCUSSION

Respondents to the questionnaire were a wealthier and better educated group than the American population in general. According to the Bureau of the Census (1983), in 1982, 24 percent of the households in the U.S. had incomes of under \$10,000, while 5 percent of the hikers questioned fell into this category. At the opposite end of the scale, 9 percent of American households had an income of greater than \$50,000. In contrast, 23 percent of those surveyed had incomes of \$55,000 or greater.

While income distribution was similar for fee-paying and non-fee-paying hikers, there were considerably more fee-paying hikers in the over \$70,000 category. There were more non-fee-paying hikers in the \$10,000 to \$24,999 category ($p<0.05$).

Among the U.S. population over 25 in 1980, 16 percent had finished college or held advanced degrees. Respondents reported that 35 percent have college degrees and another 29 percent have advanced degrees.

Other demographic information gathered by the questionnaire included age, sex, self-described experience level, and home zip code. Respondents' ages were grouped in the young adult range between 20 and 40 years old. Among all respondents, 69 percent were male and 31 percent female with no significant difference between the hiker categories ($p<0.05$). Sixty-one percent rated their experience level as intermediate. More nonpayers rated themselves as beginners ($p<0.05$). New England, New York, and New Jersey were home to 84 percent of the hikers surveyed. Massachusetts and New York were the most heavily represented; 33 percent and 16 percent, respectively, of the hikers reported those States as home. Twelve percent of the sample were from elsewhere in the U.S. and 4 percent claimed foreign addresses.

The first question presented hikers with six options for dealing with the current decline in backcountry management budgets, and asked them to pick the one that best expressed their feelings. The largest number of respondents chose budget reallocation; this was probably the easiest answer, supporting the status quo without calling for a tax increase (table 1). It reflected a feeling that the Nation's budget priorities are inappropriate. Fifty-one percent of the respondents gave an answer that indicated a desire to see continued full government support of backcountry recreation: reduced management, increased taxation, or reallocation of budgets.

The support for fees or volunteerism alone is slight. However, 42 percent of the respondents supported either fees or fees and volunteerism. The respondents who supported either volunteerism or volunteerism and fees amounted to 38 percent. Thus, there was nearly the same support for fees in some form or volunteerism in some form as there is for budget reallocation. Forty-nine percent of the respondents indicated they perceive a need for partial support of backcountry services by recreationists by answering fees, volunteerism, or fees and volunteerism.

Table 1.--Means of supporting backcountry management (In percent)

	Hiker Category		
Options	Fee	Non-fee	Total
Reduce management	1	2	1
Increase taxation	7	6	6
User fee	10	12	11
Increase volunteerism	6	7	7
Fees plus volunteerism	33	29	31
Reallocate budgets	44	45	44
Total	101	101	100

n= 555
Due to rounding error, not all columns total 100%.

One of the ideas proposed to reduce costs of backcountry services to the government is to let concessionaires provide them. The questionnaire asked hikers to choose which of the following three sectors should provide backcountry recreation: the government, the nonprofit sector, or the profit sector. Respondents could choose as many categories as they cared to. Summary results are found in table 2.

Neither fee-payers nor non-fee-payers were particularly supportive of profit-making concessions providing backcountry services except in combination with the government and the nonprofit sector. Overall, respondents favored government, nonprofit, and combined government and nonprofit provision of services in roughly equal proportions. Fee-paying hikers tended to favor nonprofit involvement more than non-fee payers. This may result from greater familiarity with nonprofit organizations on the part of fee-payers, as most of the facilities they were using were run by the AMC. Non-fee-payers favored government provision of services more than the fee-payers. This may reflect a traditional view resulting from less contact with nonprofit groups, or it may reflect a distaste for nonprofit backcountry management in the White Mountains.

Table 2.--Hikers' opinions concerning who should provide backcountry recreation (In percent)

	Hiker Category		
Sector	Fee	Non-fee	Total
Government	24	37	31
Nonprofit	29	22	26
Government/nonprofit	29	27	28
Government/nonprofit/profit	12	7	9
Other	6	7	6
Total	100	100	100

n= 569

Table 3.--Hikers' opinions regarding where fee revenues should be credited (In percent)

	Hiker Category		
Fee receipient	Fee	Non-fee	Total
Treasury	7	5	6
Agency	22	20	21
Local	71	75	73
Total	100	100	100

n= 553 X^2=0.993 Not significant at 0.05 level.

A question often raised when discussing a fee system is where fee revenues should be credited. Hikers were asked to choose whether fees should be returned to the general treasury, the agency, or the local unit that collected the fee (table 3).

Respondents felt strongly that funds should be returned to the local unit where they were collected. Very few respondents wished to have fee revenues credited to the general treasury.

Any discussion of fees leads to the question, what is a fair fee? Hikers were asked this question and were asked to list whether they preferred a daily fee, a yearly fee, or no fee. Some respondents offered both daily and yearly fees. Thirty-four percent of the respondents responded that no fee is most reasonable.

For day use, the preferred fees tend to center on \$2 per day (fig. 1). There is a node at \$5 per day that is probably due to the fact that it is a round figure and one for which making change is

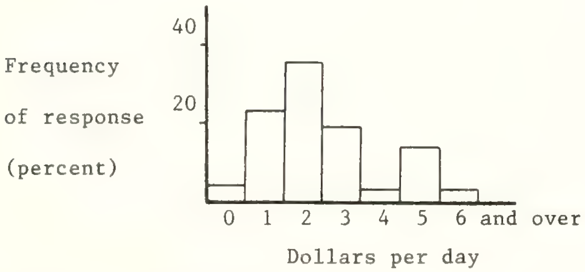

Figure 1.--Reasonable price for a daily fee.

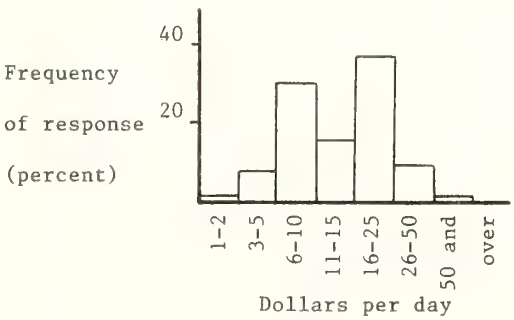

Figure 2.--Reasonable price for an annual fee.

easy. The difference between distribution for payers and nonpayers was slight. More fee-payers saw \$5 per day as reasonable while more non-fee-payers saw \$1 per day as acceptable.

The distribution differences between payers and nonpayers in the cost-per-year histogram were slight except at the extremes of the scale (fig. 2). More fee-payers thought yearly fees in the \$26-\$50 range were appropriate and more non-fee-payers thought that fees in the \$3-\$5 range were appropriate.

Knowing that there are a number of areas in the Northeast in which one might have to pay a fee related to outdoor recreation, hikers were questioned as to whether they had ever paid a fee. The results show that a number of hikers misinterpreted the question, as 100 percent of the fee-paying population should have answered yes to this question. In fact, only 81 percent of them did (table 4).

Significantly fewer non-fee hikers reported that they had paid a fee ($p<0.05$). Almost two-thirds of the non-fee hikers had had previous experience with fees.

Table 4.--Response to questions regarding prior experience with fees (In percent)

	Hiker Category		
Response	Fee	Non-fee	Total
Yes	81	63	71
No	19	37	28
Total	100	100	99

n= 580 X^2= 23.370 Significant at 0.05 level.
Due to rounding error, not all columns total 100%.

Hikers were asked how their hiking experience would be affected by paying a fee or carrying a permit (table 5). Fifty-seven percent felt that the effect would be neutral, while 39 percent felt it would have a negative impact.

Hikers were asked for their feelings about seven means of collecting fees. Respondents were of mixed opinion concerning four of the fee collection systems: licenses, windshield stickers, entrance fees, and search and rescue

Table 5.--How fees would affect hikers' experiences (In percent)

	Hiker Category		
Effect	Fee	Non-fee	Total
Negative	40	38	39
Neutral	54	60	57
Positive	6	3	4
Total	100	101	100

n= 563 X^2= 4.303 Not significant at 0.05 level.
Due to rounding error, not all columns total 100%.

Table 6.--Hikers' reactions to seven fee collecting systems (In percent)

Fee system	Favor	Neutral	Oppose	Total
	Reaction			
License	30	21	48	99
Windshield sticker	30	24	46	100
Entrance fee	33	22	45	100
Multiple fees	19	18	63	100
Rescue insurance	40	27	33	100
Equipment tax	15	16	70	101
Contribution	56	26	18	100

Due to rounding error, not all rows total 100%.

Table 7.--Response to question about respondents volunteering (In percent)

Response	Hiker Category: Fee	Non-fee	Total
Yes	10	11	10
No	90	89	90
Total	100	100	100

n= 565 $X^2 = 0.278$ Not significant at 0.05 level.

Table 8.--Response to question concerning respondents contributing money (In percent)

Response	Hiker Category: Fee	Non-fee	Total
Yes	33	19	26
No	67	81	74
Total	100	100	100

n= 566 $X^2 = 14.496$ Significant at 0.05 level.

insurance (table 6). Response distributions were similar for fee-payers and non-fee-payers. Written and verbal comments indicated that opposition to these techniques was in some cases due to concern about their enforceability.

A majority of respondents were opposed to multiple fees, and excise taxes. There was no significant difference between the responses of fee-payers and non-fee-payers ($p<0.05$). A small majority favored voluntary contributions. Significantly more fee-payers approved of this system than non-fee-payers ($p<0.05$). Comments about contributions indicated that some of those who opposed them felt that they would be ineffective for raising necessary revenues. Their fear may be justified. Only 28 percent of those who favored contributions had actually made a contribution for backcountry maintenance. (Contributions toward trail work and search and rescue efforts are actively solicited at AMC huts and shelters.)

The final questions asked hikers whether they had contributed to backcountry management financially or by volunteering. Responses to the question about volunteering were very similar between the two hiker categories (table 7). There was a significant difference ($p<0.05$) between the responses of fee-payers and non-payers to the question about financial contributions (table 8).

CONCLUSIONS

The results offer insights into the acceptability of fees to hikers in the White Mountains. Responses to the first question on the questionnaire indicated that almost half of the respondents perceived a need to supplement government funding of backcountry recreation. It is likely that these hikers would be willing to pay a fee that was considered fair.

Thirty-nine percent of the respondents felt that fees would have a negative effect on their experience. In response to the question about what amount would be a fair fee, roughly one-third replied by answering "no fee." These data support the findings of Kemsley (1978), Rupe and others (1979), and Godin (1984) who found that between two-thirds and 60 percent of the hikers they surveyed were willing to pay fees. Respondents to the NPCA questionnaire (1985) were less inclined to accept fees although a slight majority were willing to pay them and only one-third would reduce trail use due to fees. These findings suggest that roughly two-thirds of the hikers in the White Mountains would be willing to pay fees if necessary, even though some of them feel that the government should fully support backcountry recreation.

McCurdy (1970) and Manning and Baker (1981) found that about 60 percent of the users of developed recreation fee sites accepted the use of fees. This leads to the observation that about 40 percent of the users of those sites were paying fees even though they disapproved. It is possible that many of the backcountry visitors in the White Mountains who say they are opposed to fees would pay them if necessary.

The results also suggest characteristics that would make a fee system acceptable to the public. Respondents felt strongly that fee revenues should be returned to the most local unit of the land managing agency possible. This finding supports Kemsley's (1978) results that showed strong support for application of fee revenues to projects related to hiking. Fees returned to local agency units are most likely to be credited toward backcountry recreation management.

There is talk of having private concessionaires manage backcountry and collect fees. Hikers in the White Mountains would prefer to have backcountry managed by some combination of the government and nonprofit organizations.

The only outstanding support was for a system of voluntary contributions. It may be that respondents who favored this method were hoping

"the other guy" will make the contribution; only 28 percent of them had actually made contributions. Excise taxes and separate fees were disliked by enough hikers that they should probably not be considered. One of the reasons that hikers do not support certain systems is that they fear they will not be enforceable.

The results concerning differences in attitudes between fee-paying and non-fee-paying respondents are ambiguous. Responses to some questions showed significant differences while others did not. Responses to the question about the effect of fees on hikers' experiences showed no significant difference between categories. It is possible other factors are more important than fees when White Mountain hikers make decisions whether to use fee services or not.

Although the demographics show that hikers in the White Mountains are generally affluent, there are hikers at the low end of the income scale. Even considering that some of those who are counted as low income are probably students who underestimate their family income, there are low income people who live close to the public land and are able to use it. Managers should consider these people as they make decisions about fees.

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REFERENCES

Appalachian Mountain Club Hut System. 1980 hut user survey. Unpublished data on file at: Appalachian Mountain Club Research Department, Gorham, NH; 1980.

Appalachian Mountain Club Research Department. 1983 shelter user survey. Unpublished data on file at: Appalachian Mountain Club Research Department, Gorham, NH; 1983.

Cowperthwaite, Albro. Recreation fees in the North Maine Woods. In: Fees for outdoor recreation on lands open the the public: proceedings of a conference; 1984 January 12, 13; Durham, NH. Gorham, NH: Appalachian Mountain Club Research Department; 1984: 139-145.

Driver, B.L. Public responses to user fees at public recreation areas. In: Fees for outdoor recreation on lands open to the public: proceedings of a conference; 1984 January 12, 13; Durham, NH. Gorham, NH: Appalachian Mountain Club Research Department; 1984: 69-72.

Economics Research Associates. Evaluation of public willingness to pay user charges for use of outdoor recreation areas and facilities. Prepared for U.S. Department of the Interior, Bureau of Outdoor Recreation; 1976. 45 p.

Godin, Victor B. Backcountry user reaction to user fees. In: Fees for backcountry recreation on lands open to the public: proceedings of a conference; 1984 January 12, 13; Durham, NH. Gorham, NH: Appalachian Mountain Club Research Department; 1984: 32-37.

Graefe, Alan R.; Vaske, Jerry J.; Kuss, Fred R.; [and others]. Visitor perceptions and attitudes towards restricted use policies in the White Mountain National Forest. Unpublished paper on file at: Appalachian Mountain Club Research Department, Gorham, NH; 1984.

Johnson, Randy. Backcountry fees: a working example at Grandfather Mountain. In: Fees for outdoor recreation on lands open to the public: proceedings of a conference; 1984 January 12, 13; Durham, NH. Gorham, NH: Appalachian Mountain Club Research Department; 1984: 136-138.

Kemsley, William Jr. Hikers' tax? Results of the Backpacker readers' poll. Backpacker 27. 6(3): 26-28; 1978.

LaPage, Wilbur F. The role of fees in campers' decisions. Res. Pap. NE-118. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1968. 24 p.

Manning, Robert E.; Baker, Sidney C. Discrimination through user fees: fact or fiction? Parks and Recreation. 16(9): 70-74; 1981.

McCurdy, Dwight R. Recreationists' attitudes toward user fees: management implications. Journal of Forestry. 68: 645-646; 1970.

National Parks and Conservation Association. NPCA survey response: fees are ok, taxes are not. National Parks. 59(5-6): 39; 1985.

Rupe, M. L.; Leonard, R. E.; Lindsay, J. J. Hikers' views of backcountry management. Research Report SNR-RM6. Burlington, VT: School of Natural Resources, University of Vermont; 1979. 18 p.

U.S. Department of Commerce, Bureau of the Census. National data book and guide to sources: statistical abstract of the United States 1984. 104th ed. Washington, DC: U.S. Department of Commerce, Bureau of the Census; 1983. 1015 p.

Van Meter, Larry. Fees for trail shelters. In: Fees for outdoor recreation on lands open to the public: proceedings of a conference; 1984 January 12,13; Durham, NH. Gorham, NH: Appalachian Mountain Club Research Department; 1984: 124-125.

WILDERNESS INFORMATION SPECIALISTS AT PORTALS: INFORMATION DISSEMINATORS AND GATHERERS

John H. Schomaker and David W. Lime

ABSTRACT: Volunteer information specialists at access points to the Boundary Waters Canoe Area Wilderness were able to gather information on visitors and their trips. Some data were gathered more consistently than others. Uses of the gathered information include: scheduling contact people; identifying information that users want; and getting an early indication of new management concerns.

INTRODUCTION

Evaluation is an important and necessary part of the management cycle--set goals and objectives, implement a program, and measure effectiveness (Theobald 1979). Evaluation in wilderness management, as in all management, is the basis of control (Haynes and others 1975, p. 285). In addition, evaluation is a responsibility that accompanies public agency accountability (Connolly 1982). To fulfill that responsibility in a service area like recreation, consumer feedback must be sought. Consumer feedback is particularly appropriate in evaluating effectiveness when, as in wilderness recreation (Czepiel and Rosenberg 1977):

1. an effective market mechanism is absent;

2. the service is a complex system;

3. control over the many elements of the service and delivery system is loose;

4. the product is of great psychological importance to the consumer;

5. government regulation and scrutiny are present;

6. consumers are relatively sophisticated or "upscale."

Two basic strategies are available for getting feedback from consumers--observation and self reports (Clark 1977). Observations can be made as a participant or non-participant. And, the observations can be of the actual behavior as it occurs or of traces of behavior. Self reports normally are obtained through interviews or questionnaires, although unsolicited complaints and compliments may also be used. Self reports may be sought with varying levels of formality. Interviews, for instance, can be highly structured and follow a particular, rigid format, or they can be informal and cover particular topics in a conversational style.

In general, data from structured observations, interviews, and questionnaires are easier to analyze than data from less structured techniques. However, structured interviews and questionnaires also may be more obtrusive than observation and less structured interviews. The degree to which a technique affects the respondent is a particular concern when one is dealing with wilderness recreationists, because managers and researchers want to minimize any intrusion on the wilderness experience. The difference between a structured interview and an unstructured, conversational interview with a wilderness recreationist might be seen, in the extreme, as the difference between an oral examination and a helpful chat.

PURPOSE

Our purpose in this study was to determine whether agency people located at wilderness entrances could obtain information from recreationists through unstructured, conversational interviews and observation that would be useful in evaluating wilderness management programs.

WILDERNESS INFORMATION SPECIALISTS

Managers of several wilderness areas have placed people at entrances of the wilderness to serve as information contacts. Notable examples where contact people have been used routinely and over an extended period of time include the Selway-Bitterroot and Eagle Cap Wildernesses in Idaho and Oregon, respectively. Managers of other wildernesses have used contact people intermittently at entrances, either as their budget allows or during high use periods.

The goal of these programs has been to reduce impacts of visitors in the wilderness through indirect techniques rather than the more direct approach of regulations and enforcement. The use of contact people is consistent with Lucas' (1983) suggestions to develop non-regulatory visitor management and to regulate before entry into the area rather than after.

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The duties of the contact people, often called wilderness information specialists (or WISes, for short), have included: (1) issuing permits, (2) educating visitors, (3) providing information, and (4) collecting information. The value of mandatory permits has been pointed out by Hendee and Lucas (1973). The educational goals include increased knowledge about no-trace camping, the Wilderness Act, the natural role of fire, and fire prevention (Bradley 1979). Information is provided to better disperse visitors throughout an area. Information is collected to learn where visitors are going, which is helpful in the dispersal program, and where visitors reside, which is helpful in determining where off-site educational efforts should take place (Bradley 1979). Our purpose was to further explore the collection of information by WISes.

STUDY AREA

We worked with WISes of the Boundary Waters Canoe Area Wilderness (BWCAW), Superior National Forest, in northern Minnesota. This one million acre wilderness attracts approximately 140,000 visits annually. Management problems in the past have included overused campsites, litter, and concentrated use along popular routes. In response to such problems, the Superior National Forest has implemented certain regulations. Visitors are allowed to camp only in designated sites, cans and bottles are prohibited, and party size is limited to 10 people.

A limited number of permits are issued for each of the 87 entrances for each day of the summer use season. Forest Service personnel issue permits in their offices and visitor centers. Forest Service cooperators--canoe outfitters, resorts, camps, and bait shops--also issue permits. When people get permits, they are asked to review a black notebook that contains the rules of the wilderness in pictures. They also are shown a map of heavily used areas and are given a list of regulations to take with them. The purpose of these efforts is to ensure that visitors know what proper behavior is in the area and where they might go to avoid the most heavily used areas.

METHODOLOGY

Volunteers were recruited by the Superior National Forest for a variety of jobs during the 1983 summer season. From the pool of applicants, a few were selected to serve as WISes for part of their duties. The selection of volunteers is important (Greer 1984), especially when they are to be used as WISes (Bradley 1979). We instructed four volunteers on how they should approach visitors and the kind of information we wanted them to collect. They were instructed to gather as much information as possible in friendly conversation with the visitors and to record the information on a structured form immediately after the visitors left the wilderness landing. The volunteers were instructed to act as good hosts. In brief, we told them to be friendly, alert, and attentive. In collaboration with Superior National Forest managers, we identified information that could be gathered by the WISes and developed the form for recording it. Information was gathered on the time and place of the contact, characteristics of the groups, characteristics of trips, permit acquisition and compliance, information desired by the visitors, and numerous impressions by the WISes (fig. 1).

SAMPLE

Between June 29 and August 26, 1983, the WISes contacted 619 groups at three BWCAW landings. Most of the sample groups (90%) were contacted at the Lake One landing, one of the most heavily used wilderness portals. About 60% of the groups were contacted as they started their trip, the rest as they were finishing.

FINDINGS

After the sample period, the data were compiled from the forms completed by the WISes. We report our findings in two parts: 1) what the WISes learned that was useful to managers, and 2) what we learned about the technique of conversational interviews.

Information useful to managers.--By recording the time that groups arrived at the landing, either to enter or leave the wilderness, the WISes provided information useful in scheduling scarce person-hours at entrances. Schedules would differ depending on whether one wants to contact groups when they are entering or leaving the area (fig. 2). Also, most groups spend enough time at the landing (mean = 40 minutes) that a few minutes talking with a WIS would not significantly interfere with their activities.

Information gathered about the issuance of a wilderness permit proved useful soon after this study began. The contact people learned that groups who received their permit from a particular outfitter had not seen the black notebook that summarized rules and regulations. Because this notebook is an important part of the education and information program, the managers considered this apparent oversight serious. Based on the reports of the WISes, the forest staff was able to remind the outfitting service early in the season about its responsibility and the problem was solved.

Fifty-five percent of the groups contacted had gotten their permit from the Forest Service; 45% from cooperators. To compare the effectiveness of the Forest Service and cooperators in educating and informing visitors, we compared groups who got their permit from the Forest Service with groups who got their permits from cooperators. We found that whether or not groups reported having seen the black notebook and the sheet of regulations did not depend on who issued their permit. However, a significantly higher percentage of the cooperators' groups had not seen the map of heavily used areas. This finding

North Central Forest Experiment Station
Superior National Forest
BWCA Access Observation Study - 1983 No. ____

[83] [ ] [ ] [ ] Observer [ ]
Year Month Day Time

Landing/Entry Point Name: ____________________

Enter/Leaving [ ] Time at Landing [ ]

[ ] Reservation [ ] Been to VC before?

Permit from? ____________________

[ ] Past visits to BWCA [ ] Past visits to this landing

Destination of group: ____________________

[ ] Mode(s) of travel [ ] Group size

[ ] Length of stay

Weather conditions: ____________________

[ ] Black Notebook [ ] Regulation Sheet

[ ] Map of Use Areas

To what extent does the group appear knowledgeable of wilderness values and ethics?

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

No knowledge or concern evident — Highly knowledgeable purist

Questions they asked or wanted to know about:

Regulations/rules they are not aware of:

Comments they made that are valuable to the Forest Service as feedback:

To what extent do you feel you were able to offer something worthwhile to the group? i.e. How much impact did you have on the group's trip?

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

Absolutely no impact — Very major changes in trip

How do you feel you were received by the group?

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7

Very negatively--they didn't want any contact — Neutral--they didn't care one way or other — Very positively--they were obviously very pleased to talk with me.

Other observations:

Figure 1.--Form used by the Wilderness Information Specialists for recording information.

has alerted the wilderness managers to a topic they can re-emphasize when talking to the cooperators about the procedures for issuing permits. Perhaps additional emphasis is necessary to explain why this information is useful to visitors and how it can help managers attain their objectives.

By recording questions and comments of people, the WISes documented what information is most desired by visitors. The most popular topics include recommended routes, information about black bears, how to avoid congested areas, the volunteer program, and where to catch fish (table 1). Such lists can serve to guide the Forest Service information and education programs.

An interesting, yet unexplained, finding was that groups who got their permit from the Forest Service were much more likely to ask about crowds and how to avoid people than groups who got their permit from a cooperator. The difference might reflect the experience of visitors. We know from our data that more experienced visitors get their permits from the Forest Service, and more experienced visitors show a greater concern for crowding and a greater desire for low-density use (Schreyer and others 1984). Or, the Forest Service may be sensitizing visitors to the issue of crowding in wilderness areas. This possible sensitizing is good, because it may cause more respect for others in the area and prompt a greater dispersal of use. However, the sensitization may also make people more aware of other visitors and decrease their satisfaction with the trip, particularly early in the trip when they may see more people on peripheral lakes and streams. The cause of the differences with respect to crowding is unresolved and merits further study.

To obtain an evaluation of the WIS program itself, we asked the WISes to record their impression of how they affected groups entering the wilderness and how they were received. These impressions are subjective, but they do give a general indication of how the WIS and visitors are interacting. The WISes felt that for about 12 percent of the entering groups they had provided information that resulted in significant changes in their trip (a rating of 5-7 on the response form). They also felt they were received well by more than 90 percent of the groups. The overall impression from the data is that the WIS program is well accepted and non-obtrusive to the visitor.

Information about the technique.--We tabulated the kinds and amount of missing data in the forms completed by the WISes (table 2). We infer that although the WISes obtained much useful information, we should have spent more time in training them because some information that was fairly easy to record often was not recorded. Information obtained through direct observation, such as the group's time of arrival at the landing, length of stay, and size, was completely and reliably recorded. Information obtained through conversation and interpreted by the observer, such as whether the visitors had been

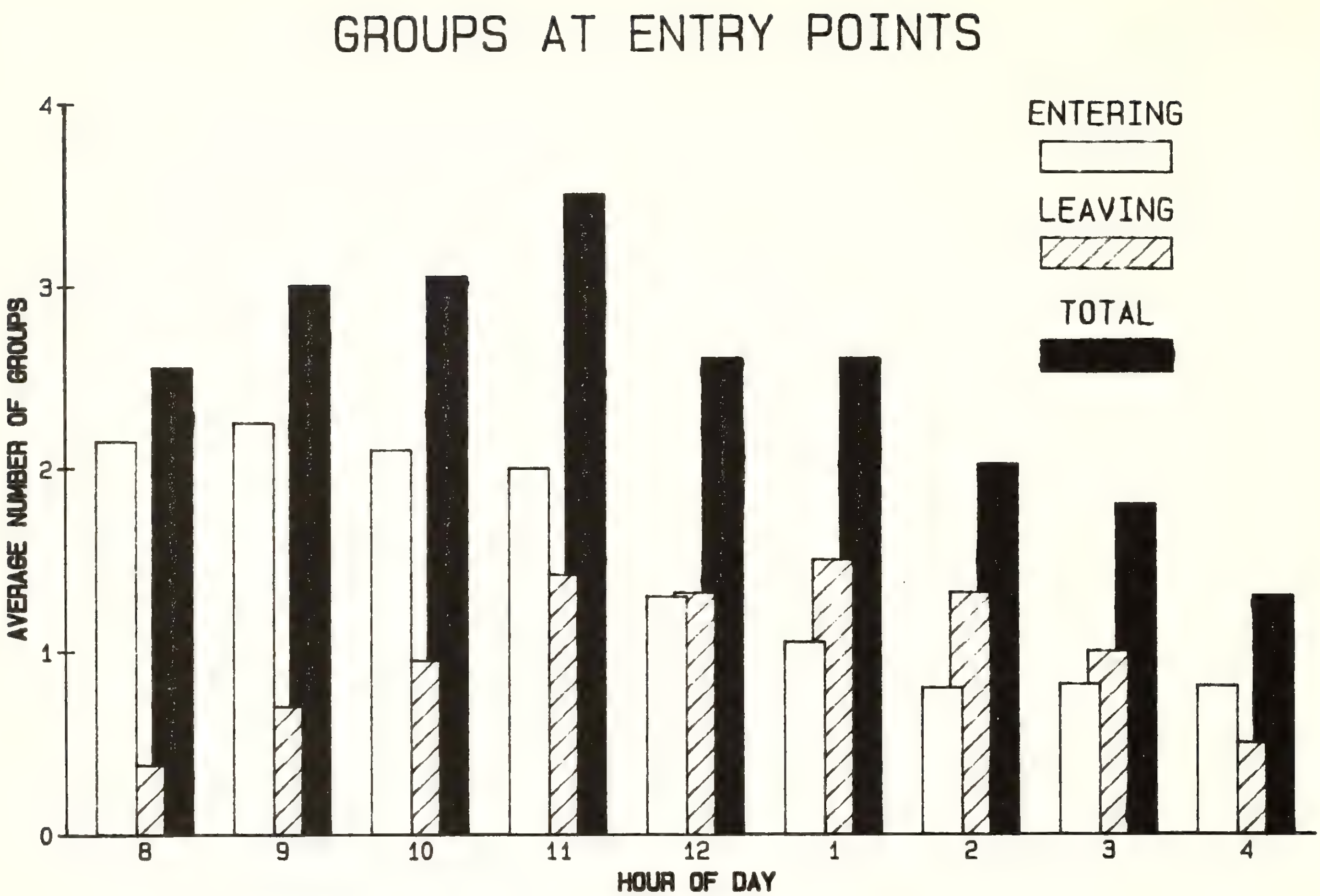

Figure 2.--Average number of groups at entry points for each hour of the day.

Table 1.--Topics of visitors' questions and comments at Boundary Waters Canoe Area Wilderness landings

Topic	Number of times mentioned		
	Who issued group's permit		Total
	Forest Service	Cooperator	
Travel routes	37	32	69
Bears	25	23	48
Crowding	30	17	47
Volunteers	19	20	39
Fishing	20	14	34
Weather	11	8	19
Campsites	11	7	18
Drinking water	9	6	15
Bugs	5	10	15
Nature	7	7	14
Rules	5	8	13
Permits	8	4	12
Canoe equipment	3	7	10
Safety	3	4	7
Birds	3	4	7
Fire	2	3	5
Miscellaneous topics mentioned less than five times each	41	45	86

Table 2.--Data missing from the 619 forms completed by Wilderness Information Specialists of the Boundary Waters Canoe Area Wilderness

Topic	Number Missing	Percent Missing
Does group know the rules	518	83.7
Had group seen map	339	54.8
Had group seen black notebook	255	41.2
Had group visited visitor center	225	36.3
Past visits to same landing	157	25.4
Past visits to Wilderness	120	19.4
Impact on group's trip	99	16.0
Had group seen sheet of regulations	77	12.4
Minutes group spent at landing	63	10.2
Had group made reservations	56	9.0
Did group know regulations	29	4.7
Did group have a permit	23	3.7
How was interviewer received	22	3.6
Group's length of stay	18	2.9
Group size	13	2.1
Time group arrived at landing	13	2.1
Day of week	2	<1.0
Name of landing	2	<1.0
Mode of travel	2	<1.0
Was group entering or leaving	1	<1.0
Weather	0	0.0

to the Forest Service visitor center or had seen the map of heavily used areas, often was missing or unclear. This tells us that more instruction and practice is necessary if WISes are to probe for this type of information. Our findings also confirm the importance of selecting contact people with the appropriate personality and a clear understanding of why the information is being sought and how it might be used. The volunteers selected in this study had to fill a number of roles, only one of which was a WIS. And, not all volunteers had the outgoing, personable characteristics required for a successful WIS program (Bradley 1979).

CONCLUSIONS

From this exploratory study, we are confident that wilderness information specialists at entrances can obtain information that is useful to managers in evaluating their programs. These contact people are well received by the visitors and can obtain information in a non-obtrusive way. However, great care must be used in selecting and training contact people, if complete and reliable information is to be gathered. The training should include frequent monitoring of performance of the contact people throughout the season.

REFERENCES

Bradley, Jim. A human approach to reducing wildland impacts. In: Ittner, Ruth; Potter, Dale R.; Agee, James K.; Anschell, Susie, eds. Recreational impact on wildlands: Proceedings of a conference; 1978 October 27-29; Seattle, WA. Publication R-6-001-1979. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; 1979: 222-226.

Clark, Roger N. Alternative strategies for studying river recreationists. In: River recreation management and research: Proceedings of a symposium; 1977 January 24-27; Minneapolis, MN. General Technical Report NC-28. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977: 91-100.

Connolly, Peg. Evaluation's critical role in agency accountability. Parks and Recreation. 17(2): 34-36; 1982.

Czepiel, John A.; Rosenberg, Larry J. The study of consumer satisfaction: addressing the "so what" question. In: Hunt, H. Keith, ed. Conceptualization and measurement of consumer satisfaction and dissatisfaction: Proceedings of a conference; 1976 April 11-13; Chicago. Report 77-103. Cambridge, MA: Marketing Science Institute; 1977: 92-119.

Greer, Jerry D. How to run a volunteer program. Journal of Forestry. 82(11): 660-662; 1984.

Haynes, W. Warren; Massie, Joseph L.; Wallace, Marc J., Jr. Management: analysis, concepts, and cases. 3d ed. Englewood Cliffs, NJ: Prentice-Hall, Inc; 1975. 684 p.

Hendee, John C.; Lucas, Robert C. Mandatory wilderness permits: a necessary management tool. Journal of Forestry. 71(4): 206-209; 1973.

Lucas, Robert C. The role of regulations in recreation management. Western Wildlands. 9(2):6-10; 1983.

Schreyer, Richard; Lime, David W.; Williams, Daniel R. Characterizing the influence of past experience on recreation behavior. Journal of Leisure Research. 16(1): 34-50; 1984.

Theobald, William F. Evaluation of recreation and park programs. New York: John Wiley and Sons; 1979. 204 p.

EVALUATION OF A WILDERNESS INFORMATION DISSEMINATION PROGRAM

D. L. Dowell and Stephen F. McCool

ABSTRACT: In this study a minimum impact camping program titled, "Leave No Trace," was evaluated. Results indicated an overall improvement in Boy Scouts' wilderness knowledge, skills, and behavioral intentions after exposure to the program. Retention scores, measured one month after the program presentation, showed significant decreases from post-test scores (although still above pretest scores) which suggests a strong need to reinforce newly acquired information.

INTRODUCTION

There is no question that recreational use is the source of many wilderness management challenges. Washburne and Cole (1983) found that recreationally induced impacts were viewed as a problem in more than 70 percent of the units comprising the National Wilderness Preservation System. As overwhelmingly expressed at the National Wilderness Management Workshop (Krumpe 1985), educational and informational programs are frequently viewed as the key to solving these problems, and many wilderness managers and users consider them preferable to more direct, intrusive, and regulatory techniques (Hendee and others 1978; Peterson and Lime 1979; Washburne and Cole 1983).

Washburne and Cole (1983) also reported that nearly 60 percent of the wilderness managers they questioned used informational programs to help minimize impacts. In fact, their study revealed that such minimum impact education programs were used more frequently than any other management technique. The heavy investment in and reliance on these programs indicates a faith in their ability to efficiently reduce impacts. However, the question of effectiveness is little researched in the literature. Lucas and others (1985) suggested that: "...more needs to be done to identify the key information that we supply to visitors, how to best convey this information, how to determine whether education produces the desired behavior, and finally, how to evaluate the performance of different educational approaches as well as other management strategies."

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In a review of wilderness education literature, Mercer (1984) attempted to integrate these identified needs, and suggested guidelines for future wilderness education efforts. He recommended that such education and information programs include not only techniques to reduce or avoid impacts, but also information about wilderness philosophies and values, wilderness history and policy, management techniques and tools, and the ecosystem itself. Mercer implied that effective communication of minimum-impact skills depends on an understanding of the rationale for such skills.

This paper reports the results of an experiment to evaluate the cognitive (knowledge) and affective (feelings or emotional) changes induced by a minimum-impact educational program. The program was developed jointly by the U.S. Forest Service and the Boy Scouts of America to address specific impact problems in wilderness.

LITERATURE REVIEW

While the use of informational programs and other "light-handed", non-regulatory approaches to wilderness management has long been advocated (Lime 1976; Lime and Stankey 1971; McCool 1976), only recently have we become aware of how they are being used and in what types of situations. Martin and Taylor (1981) have shown that wilderness managers frequently depend on brochures, maps, and signs to encourage minimum-impact behavior. However, they reported that managers feel that slide shows and television are the most effective media for communicating information about these behaviors.

Dowell and McCool (1983) found that 90 percent of the sampled visitors to the Bob Marshall Wilderness Area considered accurate maps to be desirable forms of information and 71 percent considered quidebooks desirable. However, only 37 percent found explanatory signs desirable. This indicates a discrepancy between what managers may be using to convey information (signs explaining minimum-impact practices) and what visitors consider desirable.

Fazio (1979) found that historical information was included in only 16 percent of the wilderness literature he examined, and only 30 percent discussed sanitation or fire prevention. Almost 60 percent of the publications discussed "wilderness manners" and 73 percent addressed equipment, safety, and comfort, indicating that skills and trip planning are often, but not always, present in visitor-oriented literature.

A variety of research has examined the effectiveness of communication media in environmental education (see, for example, Schwabb 1982;

Weiss and Knudson 1980; Zimmerman and others 1978). These studies all showed that information presented to individuals in a variety of situations can result in major shifts in knowledge levels and behavior.

In a classic field experiment, Krumpe and Brown (1982), studied the potential changes in trail selection among visitors to Yellowstone National Park backcountry. They found that 30 percent of the visitors changed their planned routes when given alternatives identified through a "backcountry trail selector" presented at ranger stations. Oye (1984) looked at cognitive and affective changes resulting from a wilderness education program directed at sixth grade students in Missoula, Montana. His study suggested that the hour-long wilderness education program significantly increased knowledge scores, but it did not change attitudes toward wilderness. However, his post-test measure was taken only the day after the treatment. No attempt was made to evaluate how long the students retained the newly acquired information.

More recently, Oliver and others (1985) tested the effectiveness of several information treatments on actual behavior in a developed campground. Their study indicates that information about appropriate behavior can reduce recreationists' impacts. Robertson's study (1982) supports this finding. She investigated the relationship between visitors' knowledge levels and appropriate wilderness behavior and found that 35 percent of the variance in behavior was explained by knowledge levels alone. However, Robertson was testing the relationship between knowledge level and behavior and not for changes in knowledge and not measuring actual changes in knowledge or behavior resulting from additional information.

Although the Oliver and others study looked at actual behavior, the program investigated was an on-site informational type, opposed to the great many off-site school and user group programs now in use. Effectiveness determined by measurable and observable behavior changes is difficult to assess in these off-site education programs, yet important because of the frequency with which they are used.
Another difficulty of off-site program evaluation is determining how long the information will be retained. Will this newly acquired knowledge be remembered a month later when a visitor is actually camping in a wilderness area? Except for the need to test for it, information retention is rarely mentioned in program evaluations. Education literature addresses short- and long-term memory, but there is no clear consensus about the most appropriate time to test this (Bruning 1983; Deutsch and Deutsch 1975; Masson and Miller 1983; Purdy and Luepnitz 1982; Slemecka and McElree 1983).

In summary, managers are concerned about reducing the impacts from recreational use through minimum impact education programs. However, many programs have not been tested for their effectiveness in changing levels of knowledge about appropriate behavior, or changing behavior. Since wilderness managers are placing a heavy reliance on these programs, testing for their effectiveness is important.

Recently, the USDA Forest Service, in cooperation with the Boy Scouts of America, developed a minimum impact educational program, titled "Leave No Trace," to affect Boy Scouts' wilderness camping behavior. The program consists of a 20-minute automated slide and tape program and associated booklet with discussion and test times. The program concentrates almost exclusively on minimum impact wilderness skills, with little discussion of wilderness philosophy, values, history, legislation, ecology, or management. Due to growing popularity of the program, interest has been expressed for a systematic, thorough evaluation of it.

Evaluating the effectiveness of the program in the cognitive and affective domains is important, but managers are seeking an actual change in behavior. Because many programs similar to the one examined here are conducted off-site, the effectiveness in changing actual behavior is difficult to assess. However, Fishbein and Ajzen (1975) offer a conceptual model that links attitudes, beliefs, and behavioral intentions as predictors of actual behavior. They define attitude as the amount of effect for or against some object, person, issue or action. Beliefs link objects to some attribute, such as "wilderness areas are places where a person can be alone." Behavioral intentions are special cases of beliefs, in which the object is always the person and the attribute is always a behavior, for example, "On my wilderness camping trip, I plan to bury all aluminum cans." Fishbein and Ajzen, in addition to a number of other researchers, have found that behavioral intentions predict actual behavior.

In this study, therefore, we not only assessed changes in knowledge about wilderness minimum impact skills, but changes in attitudes, beliefs, and behavioral intentions resulting from exposure to the minimum impact information program.

METHODS

Boy Scouts from the Missoula, Montana, area served as subjects for the experiment. Three treatments representing different components of the program were tested: (1) the slide show alone, (2) the booklet alone, and (3) the booklet and slide show combined. Because the program is designed for a wide variety of situations and because source credibility appears to be a major issue in communications research, it was decided to test for the effects of two different types of leadership situations: A Forest Service male employee in uniform and a non-uniformed female graduate student (the senior author). If no main effects were detected with this variable, it would suggest that variation in who administers the program would be acceptable.

The resulting two-factorial structure was tested using a modified Solomon four-group experimental design (Campbell 1957), and is displayed in

figure 1. This design was chosen in order to test for potential effects of the pre-test on the post-test score. This is known as the "familiarity effect." Also, it was possible to test the effect of manipulating the independent variables, communication media and source, on the dependent variable, the degree of change in cognitive and affective domain levels. In addition, the design allows for testing the effects of maturation and history. History refers to events that have occurred during the time span between the pre-test and post-test and which may affect the results. Maturation covers these effects which are systematic with the passage of time and not, like history, a function of the specific events involved (Campbell 1957). Thus, this experimental design allows the researcher to control and test for the effects of a number of possible confounding variables. As a result, a total of 14 Boy Scout troops were selected for the study. Participating troops were randomly selected to receive the treatments.

In the pre-test, each participating scout was given a test booklet one week before the treatment. The booklet contained a number of items measuring skills knowledge, and knowledge about the ecological, philosophical, managerial, and legal dimensions of wilderness. It also included beliefs, attitudes, and behavioral intentions associated with minimum-impact camping. The same document was given to scouts immediately following the treatment (the post-test score). Approximately one month after the post-test, a retention test was given using the same test booklet.

Figure 1.--Experimental design for study

Group	Pretest	Treatment	Post-test	Retention
1	X	A	X	X
2	X	A_1	X	X
3	X	B	X	X
4	X	B_1	X	X
5	X	C	X	X
6	X	C_1	X	X
7		A	X	
8		A_1	X	
9		B	X	
10		B_1	X	
11		C	X	
12		C_1	X	
13	X		X	
14			X	

A: slide show, USFS instructor
A_1: slide show, graduate student instructor
B: booklet, USFS instructor
B_1: booklet, graduate student instructor
C: slideshow and booklet, USFS instructor
C_1: slide show and booklet, graduate student instructor
X: measurement

The knowledge questions were scored (1) for a correct answer and (0) for an incorrect answer, and cumulative scores were calculated for each subsection (knowledge of skills and general wilderness knowledge). A total of 7 points was possible for the skills section, while there was a total of 16 points possible for the general wilderness knowledge section. Next, Likert-scale scores (ranging from a value of 1 to 5) were used to measure wilderness beliefs, attitudes, and behavioral intentions. These scores represented the degree of agreement with "Leave No Trace" ethics and practices. The possible points for each section were: beliefs - 20 points, attitudes - 20 points, behavioral intentions - 45 points. Table 1 shows examples of each type of item used in the study.

Table 1.--Examples of items used in the study

Skills Knowledge (Multiple Choice)

Washing in streams
- a. pollutes the water and destroys aquatic plants
- b. is acceptable when the water is rapidly moving
- c. disturbs fish only temporarily

General Wilderness Knowledge (True-False)
An ecosystem includes all the organisms of an area, their environment, and a series of linkages between them.

Beliefs (Likert Scale)

I believe the people should do whatever they want in wilderness areas.

Attitudes (Likert Scale)

I feel that wilderness doesn't need to be managed.

Behavioral Intentions (Likert Scale)

On my next wilderness camping trip, I plan to bury all aluminum and cans.

RESULTS

Preliminary analysis of results indicated that in spite of random assignment of groups to treatments, some groups differed significantly from other groups on pre-test scores, and post-test scores varied according to pre-test scores. Analysis of covariance (ANOCA) was then used to test for treatment effects. A hierarchical ANOCA (Nie and others 1975) was chosen because it controls for unequal cell sizes and for the effects of the covariate (pre-test scores) prior to testing for the main effects of the treatments.

Initial analysis indicated that maturation and history had no effect on the dependent variables. Also, the two-way ANOCA indicated that the variable concerning leadership of the program (the person making the presentation) had no significant main effects on the five dependent variables measured: (1) knowledge of skills; (2) general wilderness knowledge; (3) wilderness beliefs; (4) wilderness attitudes; and (5) behavioral intentions.

The three communication media treatments significantly affected post-test scores for wilderness knowledge, minimum impact skills, and behavioral intentions (table 2). The highest post-test scores for knowledge and skills were reported for the slide treatment, while the book seemed to have a greater effect on behavioral intentions. Post-test scores did not differ significantly for the affective domains: beliefs and attitudes. While there was some difference among the mean post-test scores by treatment, there was no major overall difference in these scores, suggesting that using the book may be as effective as the slide show. The treatment using both book and slide show sometimes resulted in slightly lower scores than either the book or slide show alone. This may be due to the length of time of the combined treatment; often, it appeared that the subjects became distracted or bored with the presentation.

The effects of the media treatments on difference scores are shown in table 3. The difference scores are simply the mean difference between the individual scout pre-test and post-test scores and indicate the absolute amount of improvement as a result of the specific treatment. The ANOCA indicates that the treatment had a significant effect on knowledge, skills, attitudes, and behavioral intentions. The combined media of book and slides resulted in the greatest improvement. This may seem contradictory to the post-test score results, however, it must be kept in mind that these are two different measurements.

Table 2.--Mean post-test scores by treatment and tested domain[1/]

Domain	Treatment				
	Control	Book	Slides	Book & Slides	Significance[2/]
Knowledge	10.99	11.14	12.22	12.02	.022
Skills	3.77	5.88	6.50	6.14	.000
Beliefs	17.36	18.06	17.71	17.97	.713
Attitudes	17.25	18.04	17.55	17.81	.549
Behavioral Intentions	33.07	38.91	37.38	37.72	.001

1/ Mean scores adjusted for effects of covariate

2/ Hierarchical analysis of covariance with pretest score as covariate; effects of covariate significant at α = .05 level for all domains.

Table 3.--Mean difference scores by treatment and tested domain[1/]

Domain	Treatment				
	Control	Book	Slides	Book & Slides	Significance[2/]
Knowledge	-.10	.19	.94	1.10	.041
Skills	-.27	2.21	2.56	2.70	.000
Beliefs	.51	.24	-.12	1.10	.167
Attitudes	-.01	.50	-.25	1.26	.052
Behavioral Intentions	1.27	3.79	1.15	4.28	.044

1/ Difference = post-test score - pre-test score; mean scores adjusted for effects of covariate.

2/ Hierarchical analysis of covariance with pre-test score as covariate; effects of covariate significant at α = .05 level for all domains.

A comparison of mean retention scores and mean difference scores between the post-test and retention score for the various communication media forms revealed no major differences. Retention scores were significantly higher than pre-test scores for knowledge, skills, and behavioral intentions. However, there were also significant decreases in retention scores compared to post-test scores for skills and behavioral intentions (table 4).

Spearman's correlation coefficients based on pre-test scores were computed among the dependent variables in order to test for strengths of association. Table 5 shows that behavioral intentions are significantly correlated with knowledge, beliefs, attitudes, and skills.

DISCUSSION

Overall, the major conclusion of this study is that exposure to the "Leave No Trace" program induced

Table 4.--Mean post-test scores compared to mean retention scores by tested domain

Domain	Mean Scores		
	Post-test	Retention	Significance[1/]
Knowledge	12.14	12.55	.058
Skills	6.37	5.81	.000
Beliefs	18.63	18.33	.172
Attitudes	18.14	17.82	.113
Behavior Intensions	38.22	36.88	.008

1/ One-tailed probability

significant, short-term changes in Boy Scouts' wilderness knowledge, skills, and behavioral intentions. Scouts who were not exposed to the program material showed little or no score improvement.

Manipulation of the communication source revealed that the effectiveness of the "Leave No Trace" program is not dependent on who presents the information. Source credibility was either unimportant to the presentation or else both uniformed and non-uniformed personnel were seen as equally credible. The program was obviously associated with the Forest Service and University of Montana, and this may have been enough to earn credibility with the scouts. The implementation of this finding is that well-designed media targeted at a specific population may be very useful even without direct presentation by agency personnel.

Generally, the evidence of affective changes in wilderness beliefs and attitudes due to participation in the program was mixed. However, scouts indicated more positive "Leave No Trace" beliefs and attitudes when exposed to the book alone and to the book and slide show in combination as opposed to the slide show alone. Perhaps the time allowed for group discussion and writing one's general thoughts on wilderness in the booklet treatment allowed scouts to think beyond skills and activities. There is no obvious explanation for the decrease in belief and attitude scores when the slide show was presented alone.

In summary, the "Leave No Trace" program effectively uses a variety of media forms to increase wilderness knowledge levels, especially knowledge of skills, which in turn affects behavioral intentions. According to Fishbein and Ajzen's theory of belief, attitude, intention, and behavior, the best single predictor of an individual's behavior will be a measure of intention to perform that behavior (Fishbein and Ajzen 1975).

Table 5.--Spearman's Correlation Coefficient for the tested domains, pre-test data

	Skills	Knowledge	Beliefs	Attitudes
Knowledge	r_s .411 sig. .000			
Beliefs	r_s -.009 sig. .927	r_s .158 sig. .124		
Attitudes	r_s .116 sig. .260	r_s .102 sig. .323	r_s .381 sig. .000	
Behavioral Intentions	r_s .199 sig. .052	r_s .460 sig. .000	r_s .363 sig. .000	r_s .239 sig. .019

Fishbein and Ajzen warn that three major factors may influence the magnitude of the relationship between intention and behavior. These are (1) the degree to which intention and behavior correspond in the levels of specificity measured, (2) stability of the intention, and (3) the degree to which carrying out the intention is completely under the person's volitional control. Level of specificity refers to specificity of the behavior itself, the target, the situation, and time. An example of a high degree of specificity is: On my next wilderness camping trip, I intend to dig a ditch around my tent. Stability of the intention refers to changes in intentions over time. Fishbein and Ajzen propose that the longer the time interval between measurement of intention and observation of behavior, the greater the probability that the individual may obtain new information or that certain events will occur which will change his intention. Thus, the longer the time interval, the lower correlation between intention and behavior. A third factor, volitional control, suggests that intentions may not be carried out if performance of the behavior requires certain abilities or resources that the individual does not possess, or if it depends on the cooperation of another person.

The specificity factor was controlled by using sound question design in the measurement instrument. Intentions were measured as specifically as possible for this study. Stability of the intention over time may be examined by considering retention scores. Retention dropped significantly for behavioral intentions within a month after presentation of the program. This suggests the further need to reinforce the "Leave No Trace" ethic and practices with some form of periodic program follow up. Ideally, a hands-on experience such as a field or camping trip may prove invaluable by ingraining the newly acquired information. One troop leader involved in the experiment decided to reinforce the program content by awarding "Leave No Trace" Boy Scout patches only after the scouts actually demonstrated appropriate minimum impact camping behaviors.

One final comment refers to the volitional control factor. It is imperative to stress leaders' active participation in the "Leave No Trace" program because their decisions and actions may strongly influence others. Scouts between the ages of 10 and 18 largely depend on authority figures as role models. Often, leaders are responsible not only for setting examples of appropriate behavior but for trip planning which may directly influence appropriate behaviors. For example, leaders' forethought in supplying garbage bags and lightweight gas stoves, as well as planning the campsite location, allows scouts the opportunity to follow minimum-impact camping practices which otherwise, when left up to their own trip planning abilities, may be impossible.

REFERENCES

Bruning, Iva L. An information processing approach to a theory of instruction. Ed. Comm. & Tech.: A Journal of Theory, Research, and Development. 31(2): 91-101; 1983.

Campbell, Donald T. Factors relevant to the validity of experiments in social settings. Psychological Bulletin. 54(4): 297-311; 1957.

Deutsch, Diana; Deutsch, J. Anthony. Short-term memory. New York: Academic Press, Inc.; 1975.

Dowell, L. L.; McCool, Stephen F. Information: a management tool to help optimize wilderness users' satisfaction. In: McCool, Stephen F., ed. The Bob Marshall Wilderness visitor study. Missoula, MT: School of Forestry, University of Montana; 1983: 62-83.

Fazio, James R. Communicating with the wilderness user. Bulletin no. 29. Moscow, ID: U.S. Dept. of Ag., Forest Service, University of Idaho Forestry, Wildlife, and Range Experiment Station; 1979.

Fishbein, Martin; Ajzen, Icek. Belief, attitude, intention and behavior: an introduction to theory and research. Reading, MA: Addison-Wesley Publishing Co.; 1975.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Miscellaneous Publication WO-1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 381 p.

Krumpe, Edwin E.; Brown, Perry J. Redistributing backcountry use through information related to recreation experiences. Journal of Forestry. 80: 360-364; 1982.

Krumpe, Edwin E. Moving into action. In: Issues in wilderness management: proceedings, 1st national wilderness management workshop; 1983 October: Moscow, ID: Westview Press Inc.; 189-201; 1985.

Lime, David W.; Stankey, George H. Carrying capacity: maintaining outdoor recreation quality. In: Recreation symposium proceedings; 1971 October 12-14; Syracuse, NY: 174-184; 1971.

Lime, David W. Principles of recreational carrying capacity. In: Proceedings of the southern States recreation research applications workshop; 1975 September 15-18; Asheville, NC. General Technical Report SE-9. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 122-134; 1976.

Lucas, Robert C.; Cole, David N.; Stankey, George H. Research update: what we have learned about wilderness management. In: Issues in wilderness management: proceedings, 1st national wilderness management workshop; 1983 October; Moscow, ID: Westview Press, Inc.; 173-185; 1985.

Martin, Burham H.; Taylor, Dorothy T. Informing backcountry visitors: a catalog of techniques. Gorham, NH: Appalachain Mountain Club; 1981.

Masson, Michael E. J.; Miller, Jo Ann. Working memory and individual differences in comprehension and memory of text. Journal of Educational Psych. 72(2): 314-318; 1983.

McCool, Stephen F. Strategies and techniques for managing dispersed recreation in national parks. In: proceedings of the 3rd resources management conference; 1976 April 29-30; Fort Worth, TX: U.S. Department of the Interior, Southwest Region; 259-290; 1976.

Mercer, John. In search of the ideal document: a problem analysis of literature-based wilderness education efforts. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT: 1984.

Nie, Norman H.; Hull, C. Hadlai; Jenkins, Jean G. (and others). Statistical package for the social sciences. 2d ed. New York: McGraw-Hill; 1975: 379, 405-408.

Oliver, Susan S.; Roggenbuck, Joseph W.; Watson, Alan E. Education to reduce impacts in forest campgrounds. Journal of Forestry. 83(4): 234-236; 1985.

Oye, Gary A. Wilderness education: evaluation of a sixth grade approach. 1984. Unpublished thesis on file at: University of Montana Library; Missoula, MT.

Peterson, George L.; Lime, David W. People and their behavior; a challenge for recreation management. Journal of Forestry. 77(6): 343-364; 1979.

Purdy, Jesse E.; Luepnitz, Roy R. Immediate and long-term retention for pictorial and verbal stimuli. Perceptual and Motor Skills. 55(3) pt. 2: 1079-1082; 1982.

Robertson, Rachel D. Visitor knowledge affects visitor behavior. In: forest and river recreation: research update. Proceedings of a symposium on leisure research; 1981 October 25-27; Minneapolis, MN: Misc. Pub. 18, 1982. St. Paul, MN: Dept. of For. Resources, University of Minnesota; 1982: 49-51.

Schwabb, Karl E. Instructional methods: their use and effectiveness in environmental education. Journal of Environmental Education. 14(2): 8-12; 1982.

Slamecka, Norman J.; McElree, Brian. Normal forgetting of verbal lists as a function of their degree of learning. Journal of Experimental Psych.: Learning, Memory, and Cognition. 9(3): 384-397; 1983.

Washburne, Randall F.; Cole, David N. Problems and practices in wilderness management: a survey of managers. Research Paper INT-304. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 56 p.

Weis, Charles N.; Knudson, Douglas M. Naturalists and the mass media reaching beyond the parks. Journal of Environmental Education. 11(4): 41-44; 1980.

Zimmerman, Donald E.; Scherer, Clifford; Larson, Mark. The use of conservation and environmental mass media by Pennsylvania educators. Journal of Environmental Education. 10(2); 43-48; 1978.

COMPUTER VERSUS BROCHURE INFORMATION DISSEMINATION AS A BACKCOUNTRY MANAGEMENT TOOL

Michael G. Huffman and Daniel R. Williams

ABSTRACT: This study compared the effectiveness of two decision aids, a brochure and a microcomputer, in influencing backcountry visitors at Rocky Mountain National Park to consider less used sites. Both decision aids were significantly effective in redistributing visitors to designated sites with the computer being more effective than the brochure.

INTRODUCTION

From the late 1960's through the 1970's participation in backbacking and hiking experienced phenomenal growth. In 1965, 7 percent of the U.S. population was estimated to participate in backpacking and hiking. By 1977, this figure had grown to 28 percent (Knudson 1984). As a result, many national parks and forests saw tremendous increases in backcountry visitation. While growth in backcountry recreation seems to have stabilized, the number of backcountry visitors each year remains high. In 1983 the national parks recorded 2,579,715 overnight backcountry visits compared with the peak of 2,608,862 in 1976 (National Park Statistical Abstract 1984).

Concern has been expressed over such high levels of use (overuse) (Cordell and Hendee 1982; Lime 1977). Specifically, Krumpe (1979) pointed to the following impacts that can be associated with overuse of the backcountry: loss of ground cover, compacted soils, numerous blackened fire rings, littering and garbage, improperly disposed human waste, chopping of trees and branches for firewood, and erosion caused by excessive trail use and the cutting of switchbacks. In addition to impacts on the physical resource, overuse can adversely affect the visitor's backcountry experience. Lime (1977) stated that for many visitors, general congestion at recreation sites is a major source of user dissatisfaction. Thus, the number of visitors is negatively correlated with visitor satisfaction. While this relationship appears to be rather straightforward, Hammitt (1983, p.312) has suggested that visitors can perceive crowding even though they encounter relatively few visitors during their trip. He stated that people may be predisposed to certain environmental cues such as large amounts of litter or extensive trail erosion that "serve to forewarn them of possible restrictions created by social density."

It becomes clear that as levels of backcountry use remain high, managers will continue to be challenged by the problems of protecting the natural resources of recreation areas while providing visitors with opportunities for quality backcountry experiences. What types of strategies are available that might help to rectify this situation? Redistribution of use has been suggested as one possible alternative. Krumpe and Brown (1962, p.360) stated that "while evenly distributed use might undesirably spread impacts over a wide area, concentrated overuse can degrade both the resource and the social aspects of the backcountry experience."

INFORMATION AS A MEANS OF REDISTRIBUTING WILDERNESS USE

Influencing user redistribution through information dissemination has been advocated by wilderness researchers for many years (Krumpe 1979; Krumpe and Brown 1982; Manning and others 1981. Lime and Lucas (1977) identified several advantages to this approach. First, they pointed out that this approach is non-authoritarian and can actually serve visitor's desires rather than restrict and regulate them. Second, they implied that information dissemination can be inexpensive compared to other indirect controls such as physically altering a site.

Past attempts at redistributing wilderness use with information have experienced varying degrees of success. In 1974 and 1975, Lucas (1981) attempted to redistribute wilderness use in the Selway-Bitterroot Wilderness of Montana. Visitors were provided with a brochure that presented the percentage of the area's total use contributed by each trail. The brochure was distributed at trailheads, ranger stations, and by mail to visitors who requested information on the area. Lucas discovered that the brochure did not significantly redistribute visitor use away from overused trails. He attributed its ineffectiveness to the following reasons:

1. The focus of the brochure was too narrow. He stated that visitors wanted more information concerning characteristics of the area and opportunities for other backcountry activities such as fishing.

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2. Distribution of the brochure was too limited. He stated that many people did not receive the brochure. In addition, the majority who did received it at the trailhead. Lucas believed that this was too late in the visitor's decision process for the information to be effective.

3. Many local people used the area and were not influenced by the brochure. Lucas stated that a possible reason for this was that the group's familiarity with the area made them unreceptive to additional information.

In 1979, Krumpe redistributed a substantial amount of backcountry use in Yellowstone National Park by providing visitors with a brochure and a map of lightly used trails. Distributed at visitor centers and ranger stations, this brochure asked visitors a series of questions pertaining to their preferences for natural features and backcountry activities. By answering the questions, visitors were provided with a list of trails that would meet their expressed needs. In this experiment, Krumpe (1979) used a control group and found that only 14 percent of the users in this group selected lightly used trails, while 37 percent of those in the treatment group (brochure) selected lightly used trails. This difference proved to be statistically significant.

Finally, in 1981, Roggenbuck and Berrier (1982) conducted an experiment in redistributing backcountry visitor use in the Shining Rock Gap Wilderness of North Carolina. They focused on the one overused camping area for one trail in the wilderness. Their brochure was distributed at trailheads and provided the user with information on alternate campsites including the distance of the campsite from the trail, from water, the number of campsites within the area, and the amount of vegetative screening and wind protection at each site. In addition to the provision of the brochure, they added a verbal contract by a ranger to one of the groups as well. They obtained an 82 percent reduction in use of the overused camping area. In addition, they discovered that with the exception of groups with no previous experience in the area and groups composed of three to six people, the combination of verbal communication with the brochure produced no significant increase in the reduction of camping use in the targeted area as compared with the administration of the brochure alone (Roggenbuck and Berrier 1982).

From the previous studies, several conclusions can be drawn regarding the use of information dissemination in redistributing backcountry trail use. First, information must be delivered to a large proportion of the visitors in order to be effective. Second, information must be delivered early enough to the visitors so that they will have time to use it in making their decisions. However, this does not preclude contacting the visitors on site. Finally, information should cover a wide variety of topics including site characteristics and related backcountry activities in order to effectively influence visitor decisions.

In addition to the factors listed above, each of the previous studies altered the method or medium in which the information was communicated. This implies a search for the best method or medium for providing users with information.

A NEW TECHNOLOGY FOR INFORMATION DISSEMINATION

Within the past decade the impact of computers on American society has increased enormously. It has been predicted that by the end of the 1980's, 20 percent of all American households will own a microcomputer. This is 30 times the number of computers in the world in 1982 (Hold 1982). One of the reasons attributed to this large increase in computer usage is the recent decline in cost of computer hardware. In the past computers were used only for routine record keeping (Stallings and Blissner 1984). Wilhelmi (1983) stated that because of this decline in cost, computers have become a viable alternative for new applications. One of the new uses for computers is information dissemination to the general public. Increasingly, computers have been used in visitor centers and museums to provide visitors with information about exhibits and activities (Stallings and Blissner 1984). This is probably due to the fact that computers can be designed so that their operation is so easy, users with no previous computer experience can execute programs (Cornish 1982). This may be accomplished through the use of "touch screen" computers which require the user to touch his/her selection on the screen. The computer detects the choice and responds accordingly. A second alternative is to design programs that require minimal use of the keyboard. Such programs frequently require the user to type the number of his/her selection with the aid of a numeric keyboard. Thus the standard "typewriter" keyboard is eliminated as well as the impression that typing skills are needed to use the program.

A logical consequence of the increased impact of computers is to develop a computerized backcountry information dissemination system. This seems particularly apparent in light of the recent application of computers in museums and visitor centers. The research problem addressed in this study was to determine if visitor interactive computer-based information systems were more effective in redistributing backcountry use than more traditional methods that utilize brochures. The study was conducted in Rocky Mountain National Park. This area was considered appropriate because of the high levels of use that it receives. Before describing the research methodology, the next section discusses the theoretical background used to develop the computer program and brochure.

DEVELOPMENT OF THE DECISION AIDS

Decision theory contributed heavily to the development of the decision aids of this study. Krumpe and McLaughlin (1982) have warned that the dissemination of information to visitors can appear to be deceptively easy. They stated that "information is only one element of the much

larger cognitive behavioral process that recreationists use when selecting recreation opportunities" (Krumpe and McLaughlin 1982, p.94). Further, they stated that understanding this process is important if managers are to ultimately predict and exert influence on how recreationists make decisions.

Recreation participation requires a cognitive decision process that involves multi-attribute alternatives (Krumpe and McLaughlin 1982). More specifically, this process has been defined as "a conscious mental consideration and evaluation of the characteristics of various possible courses of action in light of one's needs, goals and limitations (for example, funds, time, skills) (Gaumnitz and others 1973, p.270). From this perspective, attributes may be viewed as the perceived characteristics or qualities of alternatives.

How do individuals make decisions? Research has produced two broad categories of models: compensatory and noncompensatory. Compensatory models imply that the positive qualities which an alternative has on one evaluative criteria can compensate for negative qualities on another (Hansen 1976). Noncompensatory models, on the other hand, do not permit such attribute trade-offs among alternatives (Hansen 1976). Compensatory models have, for the most part, fallen into disfavor. Hansen (1976) discusses the major reasons in the following: First, it has been shown that they fail to represent the actual information processing techniques used by decision makers for most decision situations. Second, an alternative may look more or less attractive based upon the number of competing alternatives with which it is being compared. Compensatory models fail to consider the influence of such competing alternatives. Finally, and most importantly, compensatory models are cognitively too complex. This is due to the difficulty of observing and evaluating important attributes for all alternatives. Wright (1972) stated that while compensatory models appear to be mathematically simpler, they require more cognitive activity than do noncompensatory models.

While numerous noncompensatory models have been developed, many are not discerning enough to produce a single selection from a large pool of alternatives (Krumpe 1976). One noncompensatory model that can produce a single selection from such a pool is known as elimination-by-aspects (EBA). With this model, a decision maker first orders attributes (evaluative criteria) according to their importance. Those alternatives not satisfactory in accordance with this first evaluative criterion receive no further consideration. If this procedure does not yield a selection, the second most important attribute is adopted and the procedure is repeated. Thus the process continues until only one acceptable alternative is left.

Krumpe and McLaughlin (1982) developed a model of recreationist decision making that stated that recreation choice is a constraint-driven alternative reducing process. They defined constraints as those attributes "that have a minimum threshold level for acceptance below which rejection of the alternative would occur" (Krumpe and McLaughlin 1982, p.95). Examples of recreation engagement constraints might include cost, distance, availability, physical requirements, skills, and equipment. In addition to constraining attributes, recreationists also consider facilitating attributes which are defined as those attributes that the recreationist attempts to maximize because of their positive contribution to the total recreation experience.

Krumpe and McLaughlin (1982) incorporated the evaluation of constraining and facilitating variables into a three-stage model. In the first stage, the decision maker evaluates the alternatives eliminating any that reflect an unacceptable level for any of the constraining attributes. However this decision rule is not without exception. As an example, an individual may wish to travel no more than 50 miles to a lake to go fishing. However, a lake 65 miles away might not be eliminated from further consideration if it is known to have the largest fish in the region.

If the first stage does not produce a selection, the decision maker then evaluates the remaining alternatives based on the amount and importance of constraining attributes. This evaluation is conducted in an EBA format considering first the most important constraining attribute, then the second most important, then the third, fourth, etc.

If stage two does not produce a selection, the recreationist then repeats the EBA procedure of stage two only this time considering facilitating attributes. This procedure is repeated until a final selection is made. Because the model views recreation decision making as a constraint-driven model, it was decided that both the computer program and the brochure should address constraining attributes early in the user's decision process.

The attributes included in the decision aids were based on a study which examined visitors' evaluation of attributes that either added or detracted from their backcountry experience. The study was conducted in the Indian Peaks Wilderness of Colorado which is adjacent to Rocky Mountain National Park. Using cluster analysis, nine key clusters (dimensions) were detected. These dimensions were named: (a) fish related, (b) scenery, (c) intrusions (such as logging), (d) wildlife, (e) unique features (plants, geology, forest environments), (h) water related (streams, lakes, waterfalls), and (i) nuisances (Brown and others 1977). It was decided to include these attributes in the decision aids when applicable.

DESCRIPTION OF THE DECISION AIDS

The brochure is similar to one used by Krumpe (1979). Part of the opening paragraph states "This guide is designed to help you select a route suited to your personal backcountry preferences." It then asks users to select a preference for a particular type of topography and then directs them to the appropriate page where additional questions are presented (see fig. 1). The first questions represent constraints on the user's recreational engagement. They ask for preferences about trail distance and steepness. Questions regarding facilitators (unique features, waterfalls, opportunities for activities, etc.) follow. The brochure presents no more than four questions and eventually recommends one or more sites based on the user's responses.

The computer program was written in the computer language of MBASIC and formatted for use on a Tandy Radio Shack Model 4 portable microcomputer. It was reasoned that the majority of the people who would use the program would be relatively inexperienced with the use of computers. Thus the program needed to be extremely easy to use. Paxton and Turner (1984) stated that novices need computer messages expressed in natural language that are self-explanatory. Further, they believed that "menu-selection" is the easiest design for novices to use. They defined menu-selection as "the process whereby a set of numbered choices are displayed on a terminal screen for selection by the user" (Paxton and Turner 1984, p.142). Thus a user simply reads a question and its possible choices on the screen and then types the number that corresponds to his/her selection. Menu-selection design can take one of two formats based on the organization of questions and selection alternatives. A shallow menu tree contains a small number of menus (questions) with numerous options per menu whereas a deep menu tree contains a large number of menus with fewer options per menu. Kiger (1984) discovered that computer users prefer shallow menu trees because they require the user to answer fewer questions. Because of these findings, it was decided to use shallow menu trees for the computer program wherever possible.

The computer program presented questions in a fashion similar to the one in the brochure. Figures 2 and 3 provide examples of screens from the computer program.

ROCKY MOUNTAIN TRAIL GUIDE

While some trails in Rocky Mountain National Park receive excessive use, many offer outstanding backcountry opportunities. To select a trail based on your personal preferences, answer the following questions by typing the number of your selection beside the arrow displayed on the screen.

Do you want to select a trail?
1) Yes 2) No

Enter your selection========>

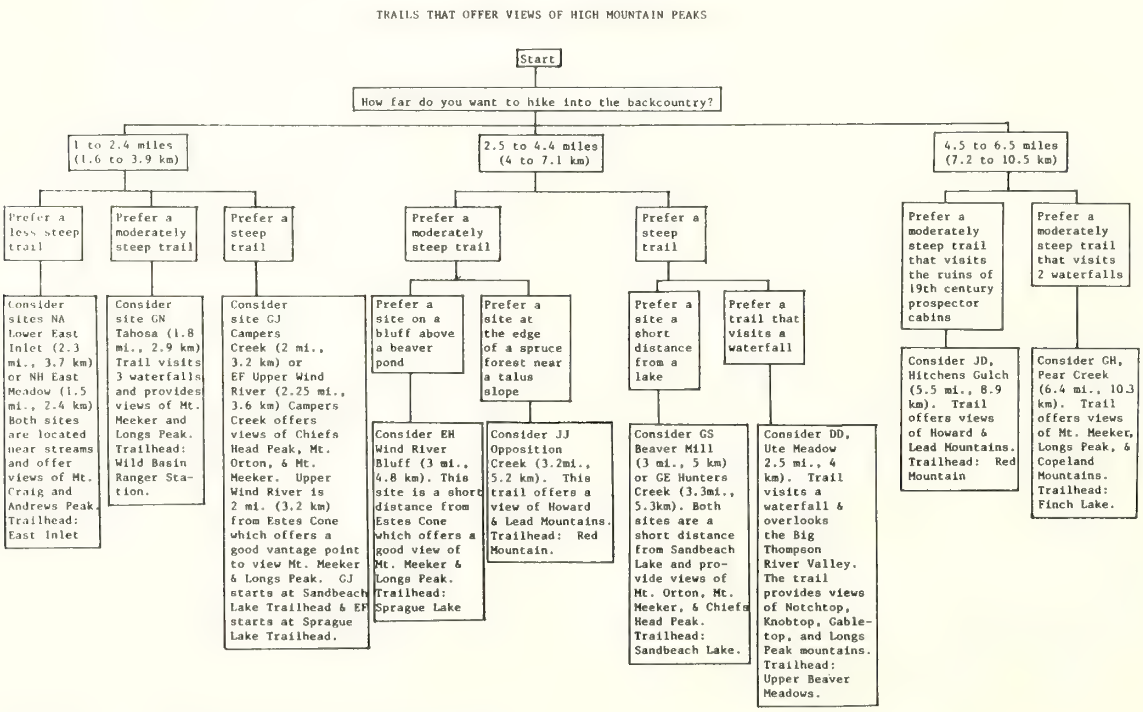

Figure 1.--Example of page from brochure.

Which of the following is most important to you when selecting a trail?

1) Distance to campsite
2) Difficulty of trail (steepness)
3) Scenery and type of terrain (peaks, lakes, streams, etc.)
4) Activities (i.e. fishing, photography, observing wildlife)
5) Solitude
6) Visiting unusual features (i.e. geological, historical)

Enter your selection========>

Figure 2.--Example of menus from computer program.

Consider NE, Solitaire, or DC, SPRUCE LAKE. NE is located near Lone Pike Lake and the trail offers views of Mt. Craig & Andrews Peak. DC visits Arch Rocks & Fern Falls. The campsite is a short hike from Loomis Lake.

DISTANCE: NE 6.21mi.(19km)	DC 4.6mi(7.4km)
ELEVATION CHANGE: NE 1629ft.(497m)	DC 1515ft.(462m)
TRAILHEAD: NE-East Inlet	DC Fern Falls

Please write the trail names listed above on the pad next to the computer keyboard and check their availability on the chart by the door.

Please type the number 2 when you are finished reading the trail description========>

Figure 3.--Example of trail recommendations provided by computer.

METHODS

The study was designed as a field experiment and was conducted in Rocky Mountain National Park from August 20 to September 15, 1984. Because approximately 90 percent of the visitors receive their backcountry permits from the visitor center near Estes Park, the sample was obtained from this location. Generalization to the larger population of park backpackers was not of primary importance and as a result no attempt was made to sample the population.

Visitors seeking backcountry permits at the Estes Park Visitor Center were randomly sampled and randomly assigned to one of three experimental groups: a control group which received information from neither the computer nor the brochure, a treatment group which received information from the brochure but not from the computer, and a treatment group which received information from the computer but not the brochure. The treatment groups were given instructions to read the brochure or use the computer before completing their permit application. After subjects had obtained their permits, they were informed that they were part of a study and asked to complete a mail-back questionnaire after their trip. At the end of each day, the permits of the subjects were examined and site selections were coded as to whether or not they had selected a route included in the decision aids. A total of 159 subjects (53 in each group) were included as part of the experiment. Permit data were obtained on all 159 subjects. One hundred fifty-six subjects agreed to complete a questionnaire, and with one follow-up mailing 146 were returned for a 92 percent response rate. Non-response checks were not considered necessary.

The questionnaire contained items which obtained: (a) the participant's previous experience in Rocky Mountain National Park as well as other areas, (b) the participant's involvement in backpacking and other outdoor activities, (c) background characteristics of the participant (age, sex, education, group size, trip length, community size), and (d) the participant's ratings of 20 trail attribute preferences. Finally, subjects were asked to evaluate the quality of the brochure or computer depending on treatment. Thus a slightly different form of the questionnaire was used for the two treatment groups.

RESULTS

It was hypothesized that subjects who received trail information from one of the two decision aids would be more likely to select a less used site (one contained in the decision aids) than would subjects in the control group. Further, it was believed that because the computer was more flexible in allowing users to choose important attributes for trail decisions, subjects who received information from the computer would be more likely to select less used sites than would subjects who received information from the brochure. To test these hypotheses, two a priori contrasts or planned comparisons were used (see table 1). Both hypotheses were supported.

Table 1.--Planned comparisons

	Standard error	D.F.	t-Value
Contrast 1 (Treatments vs. control)	.078	156	3.76*
Contrast 2 (Computer vs. brochure)	.089	156	-2.31**

*p .000
**p .022

Contrast 1 compared both experimental treatments with the control group. The difference was significant beyond the .05 level (t=-3.755, df=156, p .000). Contrast 2 compared subjects who received information from the computer with

subjects who received information from the brochure. This difference was also significant beyond the .05 level (t=-2.08, df=156, p .022). Upon examining the percentages of subjects who selected sites that were included in the decision aids, it was discovered that 17.4 percent of the control group, 38 percent of the brochure group, and 60 percent of the computer group selected such sites. Twenty-nine different sites were included in the decision aids. Both decision aids redistributed use to 16 different sites (55 percent of the 29), although the list of sites to which use was directed was not the same.

Concerning relevant background characteristics of the subjects, it was noted that 65.8 percent of the subjects selected their backcountry route either on the same day or one to two days prior to their backcountry trip. Forty-seven percent of the subjects had never visited Rocky Mountain National Park. Of the subjects who had previous experience in the park, 25.3 percent had only visited the park once. Thus individuals who had visited the park on one occasion or had no previous park experience accounted for 72.3 percent of the subjects in the study. Finally, it was noted that less than half (46.6 percent) of the subjects were from Colorado, the state in which Rocky Mountain National Park is located.

Individuals who received one of the treatments were asked to evaluate the treatment using a five-point Likert scale (5=very good, 4=good, 3=adequate, 2=poor, 1=very poor). Comparable areas of evaluation for both the brochure and the computer program included: (a) trail descriptions, (b) the number of trails included in the decision aid, (c) the variety of trails included, (d) information about opportunities for activities, and (e) the accuracy of the information presented in the decision aid. The mean ratings for each of these items for both the brochure group and the computer group were compared. In addition an overall evaluation variable was created by adding the scores for each evaluative item. A t-test was used to compare the two decision aids for each of the five evaluative areas and for the overall evaluation. Only one significant difference was found. The brochure was rated better than the computer in providing trail descriptions (t=-2.4, df=92, p .018). Because there was little dispersion among the ratings for most of the evaluative areas, it may be that the questionnaire items were not capable of detecting actual differences that may have existed in the quality of the decision aids.

In addition to the preceding items that attempted to evaluate the decision aids, the questionnaire asked subjects which source of trail information they considered most important for their trip decision taken during this study and for future trips to Rocky Mountain National Park. Sources of information included: (a) writing to the park for information, (b) information from friends, (c) information from a trail book, (d) information from topographic maps, (e) information from a ranger, (f) information obtained from previous trips to the park, (g) information from the brochure used in this study (if they were a part of that treatment), (h) information from the computer used in this study (if they were a part of that treatment), and (i) other sources of information. The results are presented in tables 2 and 3. For both current and future trips, the decision aids were the most important sources of information for subjects who had the opportunity to use them.

DISCUSSION

Krumpe and Brown (1982) stated that backcountry visitors use a variety of sources to obtain trail information. This study supports that observation. While the computer proved to be more effective than the brochure in redistributing backcountry use in this study, the brochure is still an important information source. Indeed it redistributed 38 percent of backcountry use to targeted areas.

This study has raised several questions that require further research. First, the effectiveness of decision aids in redistributing use for non-alpine ecosystems should be tested. Research by Watson (1983) suggests that backcountry trail attributes for large areas in the eastern United States can be identified and applied to the recreationist's decision process. Second, the effectiveness of decision aids in redistributing use should be tested on other populations. Would these decision aids be successful with populations that visit recreation areas prior to, during, and after peak visitation periods? Could programs be tailored for periods of high, medium, and low visitation? Third, computer technology is still a novelty for many people. Future studies should examine the effectiveness of computer programs as they become more common in everyday life. Finally, as computer technology continues to improve, applications for new hardware should be examined. Many new computers have improved graphics capabilities over machines that were the leading edge of technology just a few years ago. In addition, the cost of increased memory for computers continues to decline. This should permit the development of more sophisticated programs. Such programs could incorporate educational aspects such as minimum impact camping practices and safety in addition to the efforts to redistribute use.

In summary, the utilization of computers for information dissemination should continue to be explored. As management tools they can serve visitor's interests rather than regulate them. Finally, they have the flexibility of being altered to meet changing conditions within the environment, something not easily done with brochures that are usually printed in mass quantity.

Table 2.--Most important source of information for current Rocky Mountain National Park trip

Sources	Control		Brochure		Computer	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Write park	2	4.3	5	10	1	2
Friends	12	26.1	9	18	-	-
Trail book	6	13	8	16	4	8
Topo map	8	17.4	4	8	7	14
Ranger	11	23.9	8	16	9	18
Previous trip	5	10.9	3	6	1	2
Brochure	-	-	10	20	-	-
Computer	-	-	-	-	27	54
Other	1	2.2	3	6	1	2
TOTALS	45	97.8*	50	100	50	100

*Percentage does not = 100 due to one nonrespondent

Table 3.--Most important source of information for future trips to Rocky Mountain National Park

Sources	Control		Brochure		Computer	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Write park	1	2.2	4	8	-	-
Friends	11	23.9	6	12	-	-
Trail book	13	28.2	9	18	4	8
Topo map	9	19.6	5	10	7	14
Ranger	7	15.2	7	14	10	20
Previous trip	3	6.2	2	4	1	2
Brochure	-	-	17	34	-	-
Computer	-	-	-	-	28	56
Other	1	2.2	-	-	-	-
TOTALS	45	97.8*	50	100	50	100

*Percentage does not = 100 due to one nonrespondent

REFERENCES

Brown, P. J.; Haas, G. E.; Manfredo, J.J. Identifying resource attributes providing opportunities for dispersed recreation. Fort Collins, CO: Colorado State University; 1977.

Cordell, H. K.; Hendee, J. D. Renewable recreation resources in the United States: supply, demand, and critical policy issues. Report for the National Conference on Renewable Natural Resources, American Forestry Association; 1982.

Cornish, E. The coming of the information society. In: Cornish, E., ed. Communications tomorrow: the coming of the information society. Bethesda, MD: World Future Society; 1982. 43-49.

Gaumnitz, J. E.; Swinth, R. L.; Tollefson, J. O. Simulations of water recreation user's decisions. Land Economics. 49: 269-277; 1973.

Hammitt, W. E. Toward an ecological approach to perceived crowding in outdoor recreation Leisure Science. 5: 309-320; 1983.

Hansen, F. Psychological theories of consumer hoice. Journal of Consumer Research. 3: 117-142; 1976.

Hold, A. P. Toward the information-rich society. In: Cornish, E. ed. Communications tomorrow: the coming of the information society. Bethesda, MD: World Future Society; 1982.

Kiger, J. I. The depth/breadth trade-off in design of menu-driven user interfaces. International Journal of Man-Machine Studies. 20: 201-213; 1984.

Knudson, E. E. Outdoor recreation. New York, NY: Macmillan; 1984.

Krumpe, E. E. Redistributing backcountry use by a behaviorally based communications device. Fort Collins, CO: Colorado State University; 1979; Dissertation.

Krumpe, E. E.; Brown, P. J. Redistributing backcountry use through information related to recreation experiences. Journal of Forestry. 80: 360-364; 1982.

Krumpe, E. E.; McLaughlin, W. J. A model of recreationists' decision making prowess. In: Lime, D. W., ed. Forest and river recreation: Research update; St. Paul, MN: 1982; 94-99.

Lime, D. W. When the wilderness gets crowded . . . ? Naturalist. 14(2): 2-7; 1977.

Lime, D. W.; Lucas, R. C. Good information improves the wilderness experience. Naturalist. 14(2): 18-21; 1977.

Lucas, R. C. Redistributing wilderness use through information supplied to visitors. Resource Bulletin INT-277. Ogden, UT: U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981.

Manning, R. E.; Ciali, C. P. Recreation density and user satisfaction: a further exploration of the satisfaction model. Journal of Leisure Research. 12: 329-345' 1980.

National Park Statistical Abstract. Denver, CO: Statistical Office; Denver Service Center; U. S. Department of the Interior; National Park Service; 1984.

Paxton, A. L.; Turner, E. J. The application of human factors to the needs of the novice computer user. International Journal of Man-Machine Studies. 20: 137-156; 1984.

Roggenbuck, J. W.; Berrier, D. L. A comparison of the effectiveness of two communications strategies in dispersing wilderness campers. Journal of Leisure Research. 14: 77-89; 1982.

Stallings, G. H.; Blissner, R. H. Computer annual. New York, NY: John Wiley & Sons; 1984.

Watson, A. E. An application of behavioral decision theory to recreation site selection. Blacksburg, VA: Virginia Polytechnical Institute & State University; 1983. Dissertation.

Wilhemi, L. Microcomputer systems as exhibit controls. Curator. 26: 106-120; 1983.

Wright, P. L. Consumer judgment strategies: beyond the compensatory assumption. In: Venkatesan, M., ed. Proceedings of 3rd Annual Conference of the Association for Consumer Research. 316-324.

SITE ATTRIBUTES---A KEY TO MANAGING WILDERNESS AND DISPERSED RECREATION

Roger N. Clark and George H. Stankey

ABSTRACT: Knowledge of important recreation sites and their attributes will assist managers in evaluating the consequences of changes as a result of other resource uses on dispersed recreation opportunities both within and outside of wilderness. Such information aids in developing strategies to prevent or mitigate undesirable impacts while taking advantage of positive changes to provide a desired range of public benefits. A case example for identifying important attributes of potential recreation sites in southeast Alaska is described. Suggestions on how to incorporate this information into multiple resource planning and management are discussed.

THE PROBLEM

Knowing the importance forest visitors attach to particular features of recreational settings (called "site attributes") is the foundation of effective recreation management. Without information about these attributes, land managers cannot maintain or enhance desirable qualities, nor can they prevent or mitigate damage to recreational values as a result of other forest uses, such as timber management. There is a need for a better understanding of what attributes users require in recreation settings and how adverse impacts on these attributes can be avoided and positive effects enhanced.

It is generally accepted that recreational opportunity settings consist of three components: the <u>physical-biological setting</u> includes those qualities provided by nature, such as vegetation, topography, and water; the <u>social setting</u> includes those qualities associated with people, such as the type and amount of use in an area; the <u>managerial setting</u> includes those conditions provided by management, such as rules and regulations, developmental activities, roads, and recreational facilities (Clark and Stankey 1979). Collectively, these three components provide the conditions that give places recreational significance.

The above description provides the overall concept of recreational settings but does not identify the needed level of detail about the components and their effect on an area or a site's role in providing recreational opportunities. If, for example, resource extraction is an important part of management, what are the roles of different resource management activities, conducted in different fashions and at different times and scales, on various kinds of wilderness and nonwilderness recreation? This level of detail is necessary for good recreation planning and for evaluating how changes brought about by development will affect recreation.

SITE ATTRIBUTES: WHAT ARE THEY?

Attributes are the characteristics or qualities of a site; for example, trees, water, wildlife, facilities, easy access, solitude, flat ground, and protection. Attributes can be either positive or negative depending on one's point of view: natural vs. modified areas, or few vs. many people. User preferences identify what is acceptable and to whom.

Setting attributes can be defined at three general levels:

1. <u>Locational attributes</u>--This category includes the spatial characteristics of a site relative to the origin of the recreationist. It includes such specific measures as distance and time from home and measures the difficulty of access due to terrain and other physical-biological barriers.

2. <u>Macrosite attributes</u>--This category includes characteristics that describe the surroundings in which a recreation site is found. It includes broad descriptions of the physical, biological, and social surroundings, scenic conditions, and the type, level, and scale of modifications in the landscape. The Recreation Opportunity Spectrum (ROS)(Brown and others 1978; Clark and Stankey 1979; Driver and Brown 1978) as well as the Visual Management System (USDA Forest Service 1977) are most often applied at this level.

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3. Microsite attributes--This category involves site-specific features including most of the elements discussed earlier under the physical, social, and managerial subsettings. These features give sites recreational significance in terms of the experiences provided and affect the nature of activities that are possible. They also help identify which management actions are most likely to affect recreation use in either positive or negative ways.

A wide range of variables underlie this three-tiered attribute framework. Some variables are found in more than one category depending on the level of specificity at which they are measured. For example, broad scenic classifications might be a satisfactory level of measurement at the macrolevel; more detailed measures of scenic quality, such as the view from a campsite, might be required at the site level or microlevel.

Defining attributes contributes to an understanding of the qualities of a location that influence usage and user satisfaction. In addition to the spatial classification described above, attributes also can be classified in terms of how they operate in the recreational choice process; they may be categorized as requisite or supplementary and as facilitating or constraining.

Requisite attributes are those necessary or essential for a certain activity; for example, flat ground is necessary for camping or water is necessary for boating. Supplementary attributes are not required for an activity, but may influence people's choices; for example, scenic beauty is not necessary to engage in most activities, but is desirable for most people.

Some qualities act as facilitators or attractors: their presence allows or attracts use and increases satisfaction. Other qualities act as constrainers or detractors: they make sites difficult to use or undesirable and unlikely to meet visitors' desires. The following listing shows examples of both types.

Facilitators/ attractors	Constrainers/ detractors
Scenery	Litter
Activity opportunities (crabbing, fishing, etc.)	Resource damage
	Noise
Sheltered anchorage	Shoals
Flat spot to camp	Unprotected waters
Accessible beach	Steep ground

Thus, it is possible to organize recreation setting attributes into a variety of categories. Each provides an alternative concept of the function and purpose of attributes and how they are used in the recreationist's decisionmaking process. These different conceptions of attributes are complementary to one another; they are not necessarily mutually exclusive (fig. 1).

WHY IS A KNOWLEDGE OF SITE ATTRIBUTES IMPORTANT?

Attributes constitute the features that define an area or site as a recreational resource. Knowing what these attributes are, their relative importance to recreationists participating in different activities or seeking different experiences, and the sensitivity of the attributes to change is essential input to integrated resource management. Alterations in settings induced by nonrecreational resource uses can change greatly the type of recreational opportunities available. Conversely, maintaining the essential attributes of a particular recreational opportunity setting might represent a significant constraint on other uses. For example, a management objective to maintain semiprimitive or primitive recreation opportunities would limit the nature and extent of timber harvest activities appropriate in the

Figure 1.--Some site attributes act as facilitators or as attractors. For example, adequate flat space to camp in attracts use. Other qualities act as constrainers or detractors; for example, the presence of litter makes sites less likely to meet visitor's desires.

area. Understanding these interdependencies is essential to the integration of different resource allocations and to minimizing conflict (Clark and others 1985).

Many factors are involved in the complex decisionmaking process that recreationists undergo in considering where to go and what to do (Stankey and McCool 1985). Some of these factors are not subject to management influence (for example, the weather) or are not even related to the nature of the place or the activity (Are family or friends available with whom to recreate?). The condition of the attributes, such as those described above, is a factor, however, in the choices that many people make. Management can either directly influence these conditions or can provide recreationists with information regarding them.

Failure to accurately determine which attributes truly affect recreation choices may lead to designation or development of areas unlikely to be used. For example, Lime (1971) found that some campgrounds in Minnesota that were located and designed according to engineering standards failed to attract users; these sites were not defined as attractive by recreationists. Such mismatches can be costly in terms of agency budgets as well as in user satisfactions.

Attributes provide a basis for identifying compatibilities and conflicts with other resource uses. Because they describe setting conditions, they reveal how different uses of a setting, such as log storage and recreation use in bays and coves, produce compatibilities or conflict. Whether the situation is one where the effects of the resource use is an attractor or detractor (or has a neutral effect) depends on user preferences.

Presently, there is no systematic and objective method for identifying attributes that constitute or help define important recreation sites. We are generally unable to predict, in advance of use, what determines key recreation sites. In areas managed for timber production, for example, recreation sites and uses compatible with timber management activities are most often a result of timber management, rather than an intentional objective (Clark and others 1984). Consequently, in most cases, we do not know what may have been missed in recreation opportunities had recreation objectives been considered prior to the design and layout of roads and timber harvesting boundaries.

USE OF SITE ATTRIBUTE INFORMATION

Information about recreation site attributes can be used in all phases of ROS planning as described by Stankey and others (1984). Phase I involves a description of "what is", and such basic inventories depend on identification of the features and qualities to be inventoried. Phase II involves an identification of "what can be", a capability assessment, and provides managers with the range of suitable alternatives they might consider. Attribute data would be essential input to this analysis. In Phase III, selection of a preferred recreation alternative occurs. Attribute data are necessary to help formulate this alternative. In Phase IV, the preferred recreation alternative is incorporated into an integrated resource management program. Depending on other resource values and demands, the preferred recreation alternative might be wholly retained or modified substantially. Finally, in Phase V, the consequences and implications of the adopted integrated management alternative are appraised through a monitoring and evaluation program. This phase allows managers to determine the relationship between intended and actual consequences and to adjust, as necessary, the management actions needed to achieve their objectives (fig. 2).

A knowledge of key sites and attributes--their importance and location--aids evaluation of the magnitude and importance of potential effects of timber management activity at both macrolevels and microlevels. This involves several steps:

1. Step one is to identify actual and potential recreation sites. Onsite inventories and secondary sources such as topographical maps, nautical charts (in marine areas), and vertical and oblique low-altitude color photos are used. Criteria for selection of probable sites are developed (for example, accessibility by water for different types of boats).

2. Step two is a description of the likely impacts associated with the planned timber harvesting activity on the sites defined in step one. Measures of both the intensity and extent of the effects can be developed (Clark and others 1985). Effects include visual and sound changes in the area. A model of sound spread developed

Figure 2.--Current inventories of "what is" indicate that much of southeast Alaska is undeveloped. Future management direction to determine "what will be" will require information on supply of and demand for various forest services, including developed and undeveloped areas for recreation.

earlier (Harrison and others 1980) appears to have applicability here as do computer techniques for visual management. Impacts on sites can also be compared to other information about recreation opportunities such as visual quality and activity opportunities including fishing, hunting, and berry picking.

3. In step three, the anticipated impacts are evaluated for their consequences. A typology of impacts ranging from complete loss of the site, to no impact, to positive effects can be utilized in this process. Evaluation requires managers to examine effects in light of considerations such as: Which recreation experiences will be improved and which will be diminished? Will new and needed opportunities be created in the area? Will users be displaced? Do real choices exist for displaced visitors? What is the relative availability and accessibility of opportunity settings that will be adversely affected? What are the cumulative effects of the changes both in and out of wilderness on a regional/subregional basis? Will the effects lead to changes that exceed those judged as appropriate and acceptable in areas where limits of acceptable change have been identified? (Stankey and others 1985) (for example, will construction of logging roads or logging camps adjacent to wilderness lead to increased use within the area?). Answers to these and similar questions provide recreation managers with input to interdisciplinary teams evaluating proposed timber management plans.

4. The final step involves identifying strategies that enhance positive effects or prevent or mitigate potential adverse effects. In particular, strategies involving alternatives in timing, spacing, and design of cutting units, roads, log dumps, and so forth appear useful in contending with negative effects. In other cases, providing information to users (both area residents and tourists) about the nature of the impacts likely to be encountered will help shape realistic expectations and temper dissatisfaction. Or, alternative opportunities can be identified as a means of compensating users for the loss of favored sites. Public involvement will be necessary to determine the appropriateness of the alternatives suggested by managers.

SOUTHEAST ALASKA: A CASE EXAMPLE

The relationship between dispersed recreation use and timber management activity in southeast Alaska provides an ideal situation for studying many of the above issues. Southeast Alaska is an extensive area of natural or partially altered land. It contains outstanding opportunities for primitive and semiprimitive recreation opportunities both within and outside of designated wilderness, primarily along the thousands of miles of coastline.

Because of the planned changes in southeast Alaska from timber management and other resource management activities, there is a need to identify the nature and location of effects on recreation opportunities, to define the consequences of these impacts, and to help prescribe steps to prevent or mitigate negative effects while enhancing positive effects. There is a fundamental need to identify the location of key or critical recreation sites that presently support or have the potential to support a variety of recreational uses. This is not an easy task. The region is a marine archipelago with over 26,000 miles of tidal shoreline. Roads are generally nonexistent between communities, so boats and planes are the main means of travel outside towns (Clark and Lucas 1978). Because of the marine orientation in the region, most important recreation opportunities are close to the marine fringe. And, many of the attributes that determine desirable recreation settings along the protected shorelines are also desirable for activities associated with timber harvesting, such as log storage and transportation (Faris and Vaughan 1985).

An on-the-ground inventory of potential recreation sites would be a formidable, costly task. However, knowing the extent and location of such sites, particularly those that represent "critical recreation habitat" for regional communities, is important for specifying impacts, for identifying alternative opportunities and possible substitutes, and for developing appropriate management and mitigation strategies when important opportunities will be affected.

Information on the identification of attributes and their importance comes from managers' judgments and from research about user choices, preferences, needs, and expectations. A survey of Alaska residents in 1979-80, the Alaska Public Survey (APS) (Clark and others 1982), revealed the following attributes of favorite sites: remoteness; beaches (and other land characteristics); good boat access and moorage; good saltwater fishing; good beachcombing, hiking, and walking; wildlife and birds; undisturbed natural area; places to get away from others; and scenery.

Based on these user-defined qualities and on field study of some sites residents identified on maps, other attributes can be determined as essential (requisite attributes) for use of certain settings. For example, the need for access to the coastline and protection from winds and waves has lead to the identification of the following requisite attributes in coastal areas:

Landslope--allows easy upland activities (steep ground does not).
Tidal area--smaller areas facilitate access to beach and uplands.
Bathoslope--submarine slopes and characteristics affect anchoring ability.
Shoal--offshore rocks and reefs impede boat access to the shore.
Exposure--protection from winds and waves is a fundamental need.

Many other attributes potentially enhance or limit access to and use of the coastal margin. These include forest cover (provides privacy and protection), currents, beach type, and distance from home (fig. 3).

A key feature of the attributes identified above is that they are objective indicators and can be identified and measured from information commonly available in forest management offices. This provides a less expensive and less time consuming alternative than field inventory. By measuring the presence and variation in these attributes on maps and aerial photos, the location of potential key recreation sites can be deteermined. A probable estimate can be developed of the proportion of the region's 26,000 miles of tidal shoreline that represents a usable opportunity for dispersed recreation along coastal areas.

Onsite verification of these indicators will provide a measure of the reliability of estimates derived from maps and aerial photos. It will also refine the measures of access and suitability for recreation use. Onsite inventories also yield measures of actual site usage. How well do the estimates based on state-of-the-art knowledge represent actual user choices and preferences?

The attributes described above were measured and mapped in a pilot test along more than 80 miles of shoreline. Application of the attributes leads to the elimination of most (approximately 80 percent) of the coastline as potential "critical sites" (those with all the necessary requisite attributes for boat access and upland camping). A caution is in order here. The "surviving coastline" (the remaining 20 percent) represents potential sites based on the rationale described earlier; those sites are effective or usable for offshore access, they may or may not actually be used. This is a situation similar to the coincidence (or lack of it) between wildlife habitat and the actual occurrence of animal populations--they may or may not be found in areas of good habitat. In addition, the "eliminated coastline" may have

Figure 3.--The amount of exposed tidal area can restrict or facilitate access to beaches and uplands.

important recreation or scenic values for some types of activities and some users. Even in the worst case, where access by boat is impossible, the scenic value alone may be important for either onshore or offshore visitors to the area. However, identifying and mapping key site attributes helps to sort out the complex interactions among diverse recreation activities and potential recreation settings.

Each of the surviving sites should be considered as particularly important (or key or critical) in that they provide protection and generally unrestricted access from offshore to the uplands with some degree of flat terrain. In essence, these sites illustrate the concept of "effective recreation opportunities;" opportunities that are usable either because of their location vis a vis communities or because of physical conditions at the sites. The surviving sites in the pilot study are effective in terms of physical conditions; further application of the attributes approach in a larger area and analysis is necessary to determine the role of surviving sites in providing options for residents of nearby communities. Additional information about locational, macroarea, and microarea characteristics will help determine the significance of each of the potential sites identified.

A major advantage of the approach described is that standards for each of the attributes can be adjusted as appropriate. For example, if it is felt that too steep a bathoslope, or too small (or large) a tidal area were being considered, that could be adjusted and the section of coastline reevaluated. In this way more or less coastline would survive. Of course, such a change in standards would have to be based on a rationale consistent with user preferences and choices.

Although the preliminary focus of this study has been on the coastal margin, the concepts can be applied to recreational opportunities in upland areas. For example, while bathoslope and tidal area are potential impediments for boat access, they are largely irrelevant for upland access; flat ground and a nice beach may be desirable in either case. Other attributes beyond those described earlier must be determined for upland environments. The data resulting from the process described above then can be used to evaluate the importance of sites whether in upland or coastal areas.

CONCLUSIONS

Our research indicates that enhancing opportunities for recreation, or mitigating the effects of timber management on recreation both within and outside of wilderness, is certainly possible. Outside of areas classified as wilderness, the situation is not necessarily an either-or proposition, but more one of how to harvest while protecting key recreation values, if in fact, recreation is a use for which managers need to provide diverse opportunities. The results from this research will lead to a process

to help identify where critical areas are so that they can be considered as part of ongoing planning and management. The results also will help define what features of timber management activity are particularly important to recreationists.

The results of this research and their use in management may help to depolarize the debate about whether to log or not to log in certain areas. Studies in the Pacific Northwest demonstrate that there are important recreation values in multiple-use forests, and studies in Alaska suggest that the same might be true in some places and for some users. As indicated in a recent publication about recreation in multiple-use forests in Oregon and Washington (Clark and others 1984), "the observations and findings from this research should not be construed as an excuse to log previously unlogged areas. Rather, the results of our work indicate that when a decision is made to harvest timber for commodity values, it may also be possible to provide some quality recreation opportunities in such areas. There may also be situations, however, where silvicultural alternatives should be considered expressly for recreation, rather than production of commodities. Management objectives guide such decisions."

To make such an approach work requires that critical recreation sites be identified and their attributes measured in advance of any on-the-ground activity. In this regard, recreation is little different from fish and wildlife management; knowledge of critical habitat is fundamental in each case. With such information, it will be possible to test alternative timing, spacing, and design options for their ability to protect key recreation opportunities in areas intensively managed for timber production.

REFERENCES

Brown, Perry J.; Driver, Beverly L.; McConnell, Charles. The opportunity spectrum concept and behavioral information in outdoor recreation resource supply inventories: background and application. In: Gyde H. Lund, Vernon J. LaBau, Peter F. Ffolliott, and David M. Robinson, tech. coords. Integrated inventories of renewable natural resources: proceeding of the workshop; 1978 January 8-12; Tucson, AZ. Gen. Tech. Rep. RM-55. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1978: 24-31.

Clark, Roger N.; Gibbons, Dave R.; Pauley, Gilbert B. Influences of recreation. In: Influence of forest and rangeland management on anadromous fish habitat in western North American. Gen. Tech. Rep. PNW-178. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1985. 31 p.

Clark, Roger N.; Johnson, Darryll R.; Field, Donald R. The Alaska public survey--a comprehensive assessment of recreational values and use patterns and natural resource management. In: Proceedings, forest and river recreation: research update; 1981 October 25-27; Minneapolis, MN. Misc. Publ. 18. St. Paul, MN: Agricultural Experiment Station, University of Minnesota; 1982: 115-119.

Clark, Roger N.; Koch, Russell W.; Hogans, Mack L.; Christensen, Harriet H.; Hendee, John C. The value of roaded, multiple-use areas as recreation sites in three National Forests of the Pacific Northwest. Res. Pap. PNW-319. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1984. 40 p.

Clark, Roger N.; Lucas, Robert C. The forest ecosystem of southeast Alaska: outdoor recreation and scenic resources. Gen. Tech. Rep. PNW-66. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1978. 116 p.

Clark, Roger N.; Stankey, George H. The recreation opportunity spectrum: a framework for planning, management, and research. Gen. Tech. Rep. PNW-98. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979. 32 p.

Driver, Beverly L.; Brown, Perry J. The opportunity spectrum concept and behavior information in outdoor recreation resource supply inventories: A rationale. In: Gyde H. Lund, Vernon J. LaBau, Peter F. Ffolliott, and David M. Robinson, tech. coords. Integrated inventories of renewable natural resources: proceedings of the workshop; 1978 January 8-12; Tucson, AZ. Gen. Tech. Rep. RM-55. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1978: 24-31.

Faris, Tamra L.; Vaughan, Kenneth D. Log transfer and storage facilities in southeast Alaska: a review. Gen. Tech. Rep. PNW-174. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1985. 24 p., plus map.

Harrison, Robin T.; Clark, Roger N.; Stankey, George H. Predicting impact of noise on recreationists. Project Record. ED&T Project No. 2688. San Dimas, CA: U.S. Department of Agriculture, Forest Service, Equipment Development Center; 1980. 32 p.

Lime, David W. Factors influencing campground use in the Superior National Forest in Minnesota. Res. Pap. NC-60. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1971. 18 p.

Stankey, George H.; Brown, Perry J.; Clark, Roger N. Monitoring and evaluating changes and trends in recreation opportunity supply. In: Proceedings of an international conference; 1983 August 15-19; Corvallis, OR. Corvallis, OR: Oregon State University; 1984: 227-230.

Stankey, George H.; Cole, David N.; Lucas, Robert C.; Petersen, Margaret E.; Frissell, Sidney S. The limits of acceptable change (LAC) system for wilderness planning. Gen. Tech. Rep. INT-176. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 37 p.

Stankey, George H.; McCool, Stephen F., compilers. Proceedings--symposium on recreation choice behavior; 1984 March 22-23; Missoula, MT. Gen. Tech. Rep. INT-184. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985. 106 p.

U.S. Department of Agriculture, Forest Service. National Forest landscape management. Agric. Handb. No. 462. Vol. 2, Chapter 1. Washington, DC: U.S. Department of Agriculture, Forest Service; 1977. 47 p.

UNDERGROUND WILDERNESS: CAN THE CONCEPT WORK?

George N. Huppert and Betty J. Wheeler

ABSTRACT: For over two decades caves have been proposed for formal designation as wildernesses under the 1964 Wilderness Act. Review of the literature identifies a consistent set of values of wilderness. Some caves have all of these values. Caves within already designated wilderness areas are protected by the Act now. Some caves appear to fulfill the legal definition of wilderness as well. Federal agencies have accepted the legality of the concept of underground wilderness, although they have been slow to act. There is a risk in creating cave wilderness because of the resulting attention. Increased visitation may cause detrimental impacts. Regardless of the legal standing of caves, an enlightened management policy is ultimately required which integrates adequate protection of the surface watershed with the underground resource. Because some significant caves are not adequately protected even today, the formal designation of underground wilderness needs to be tested.

INTRODUCTION

An underground wilderness is defined as the legal designation of a specific cave as a wilderness area in its own right, under the precepts of the Wilderness Act of 1964. The idea of such designation has been debated for nearly 25 years. The germ of the movement was probably initiated by P. M. Smith in 1961 in his pamphlet entitled The Flint Ridge Cave System: A Wilderness Opportunity. This began an effort to have a major portion of Mammoth Cave designated as the Nation's first underground wilderness. The effort continues even now and is, as yet, unsuccessful in achieving its ultimate goal.

Shortly after Smith's article appeared, the lengthy report of the Outdoor Recreation Resources Review Commission was published by the University of California's Wildland Research Center. In volume 3 of that report de Saussure (1962, p. 324) considers the value of cave resources as potential wilderness. De Saussure states that three important steps need to be taken when evaluating caves for wilderness; these are as follows:

> . . .First, a comprehensive and confidential survey of known caves as to type and location and recreational and scientific value; second a coordinated policy for use of caves involving means of protection from vandalism and encouragement and rapid protection of new discoveries; finally, means should be found to permit full scientific use followed by recreational use where there is a demand for it. . .

These needs have not changed since the report was published. In addition, while notable efforts have been made by some federal agencies to recognize caves as potential wilderness areas, much remains to be done.

General works have been written in order to define underground wilderness or to justify the legal designation of specific caves as wilderness. Watson and Smith (1971) discuss the concept of underground wilderness within the greater scope of the 1964 Wilderness Act. They feel that there is precedent for underground wilderness in the provision for the establishment of an underwater wilderness in the enabling act for the Virgin Islands National Park. Weisbrod (1974) defines underground wilderness as being easily accommodated within the intent of the 1964 Wilderness Act. In "Caves: Underground Laboratories and Underground Wilderness," White (1976) describes the many scientific values of the cave environment and justifies the inclusion of specific caves into the National Wilderness Preservation System. In their article "New Wilderness Boundaries," Smith and Watson (1979) include caves among other unique wilderness areas, such as great river canyons, underwater areas, and the free air as legitimate for protection within the provisions of the Wilderness Act.

The Conservation Foundation (in Nash, 1976) itemizes the values of the natural world; the list includes material use, beauty, spiritual-symbolic, recreation, and knowledge. Hendee and others (1978) present their list of wilderness values as experiential, mental and moral restoration, and scientific. There are other listings of general wilderness values as well (Hendee and others 1968; Lucas in Hendee and others 1978). Recently Rolston (1985) composed a list of values by refining the broad concepts in the earlier lists into a detailed itemization of 12 values. It is interesting that all of these lists of wilderness values, although written by various researchers, consistently reflect similar themes.

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Caves share many of these values with surface wildernesses. A number of authors (White 1976; Zuber 1977; Huppert 1979; Glover 1985) enumerate the specific values of caves. Some of the more obvious values associated with caves are as follows.

Scientific Value

Poulson and White (1969) have written the most complete, yet concise, record of the scientific values of caves. They state that caves are ecological, evolutionary, and mineralogical laboratories. In her book, Cave Minerals, Hill (1976) highlights the usual and unusual mineral specimens to be found in the cave environment.

Culver's recent book, Cave Life: Evolution and Ecology (1982), gives much greater detail on the biological values of caves. The unusual life forms that frequent some caves add to the global diversity of the gene pool. There may be as yet unknown biologic resources in cave ecosystems. These resources may be only preserved in the pristine natural cave ecosystem.

Many caves provide suitable conditions for deposition and preservation of paleontological and archeological materials. If the remains are undisturbed they can offer a wealth of information on past ecological and human associations.

Caves can also furnish information on local and regional ground water systems. They are a unique way to get an "inside view" of ground water systems, and they sometimes provide unusual but valuable access for sampling of such water.

Finally, protected wilderness caves can provide baseline environments against which other caves can be measured. This may be their greatest scientific value because pristine surface environments for baseline data are rapidly disappearing throughout the world.

Recreational Value

Rolston (1985, p. 27) notes the two positive recreational values of wildlands as: "(a) to see what we can do (activity) and (b) to be let in on nature's show (contemplation)." There is no denying that many caves can offer a challenge to the body and spirit. The more than 6,000 members of the National Speleological Society and an increasing number of spelunking articles in popular outdoor and environmental magazines give testimony to the recreational appeal of caves.

Esthetic/Religious Value

Anyone who has toured even a few of the great commercial caves of the world can attest to their beauty. The nearly two centuries of operation of Mammoth Cave, Kentucky, as a tourist attraction is evidence of the lasting fascination that people have with the beauty of caves. Rolston (1985, p. 30) quotes William Wordsworth:

> The wilderness works on a traveler's soul, as well as on muscles and character. Mountaintop experiences, sunsets, canyon strata, or a meadow of dogstooth violets can generate experiences of "a motion and a spirit, that impels. . .and rolls through all things."

The vista of a large cave room, a glittering formation, or an underground cascade can generate the same emotions of awe as does the surface wilderness.

Historical Value

According to Rolston (1985, p. 29) places of historical value provide "a lingering echo of what we once were, a way we once passed." Caves contain many historical relics. Two famous examples include the huts built for consumptives in Mammoth Cave and the saltpeter works in many caves in the Southeast. Caves were also used as hiding places for the escaping slaves along the underground railroad, as well as Jesse James' infamous gang.

These are a few of the intrinsic values of caves. They are enough, however, to show that caves can fulfill the criteria identified by many current researchers as requisite of a wilderness area.

DO CAVES QUALIFY AS LEGAL WILDERNESS AS DEFINED BY THE WILDERNESS ACT?

The Wilderness Act (P.L. 88-577, 1964) defines wilderness in Section 2. (c) as follows:

> A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

It would seem that the concept of underground wilderness is compatible with the Wilderness Act in general terms. But whether the concept fits within the more specific terms of the Act must be evaluated on the basis of its four criteria.

First, many caves have not been affected by human activities. Some large and difficult cave systems have been traversed by only one exploration party, and no doubt there are many undiscovered passages. Such large systems exhibit a very sharp distance decay gradient for human intervention away from the entrance or commercial trail. Aley (1985) argues that the passage of just one group into a previously unexplored cave would mar it so much that it would no longer be suitable as a wilderness. This view appears to be Aley's strict personal definition of a wilderness. The Wilderness Act allows some human impacts such as signs, trails, campsites, and bridges as long as they are designed for minimal effects and are strictly controlled (Hendee and others 1978). By the strictures of the first criterion of the Act, many caves may be suitable for inclusion into the National Wilderness Preservation System.

Second, many caves can offer great opportunities for solitude and isolation. Caves, which may be many miles in length and may be difficult to traverse, are among the most challenging, inaccessible, and isolated places on Earth. This isolation may not be due to actual distance from civilization, but is the result of the time and difficulty of passage.

Third, most caves do not contain 5,000 acres and the area above them may not comprise that much land. However, caves are of such configurations that access may be readily controllable. For this reason, their preservation as wilderness areas may indeed be practical, as required in the Act. In addition, several surface wilderness areas now exist that are substantially less than 5,000 acres (Hendee and others 1978).

Fourth, there is ample evidence that many caves contain features of ecological, geological, scientific, educational, scenic, and historical value. This is well documented in the literature (Mohr 1966; Watson, P. J. 1969, 1974; White 1976; Zuber 1977; Huppert 1979; Straus 1979; and many others) and has been explained in detail above. The legal standing of these values can be verified by analogy with protective actions that have been applied to significant features on the surface. For instance the protection afforded to habitats of endangered species, or to archeological sites on the surface, should be, and is, applicable to such resources when found in caves. So the legal precedent is set for acceptance of other speleological values as suitable for consideration for protection by wilderness designation.

Apparently, caves can meet all of the four specific criteria of the Wilderness Act and could, therefore, be included into the National Wilderness Preservation System. In fact many caves are already de facto wildernesses in so far as they are managed as wildernesses without the formal designation. However, for many caves this type of management may not be enough.

There is still resistance to the establishment of any specific cave as an underground wilderness. This resistance is not only from the expected economic interests and some federal and state administrators, but also from some unexpected sources. Some recreational cave explorers oppose a wilderness designation because they fear it might lead to the closure or the restriction of access to their favorite cave. Some research scientists oppose the designation for essentially the same reason as the cavers, but pertaining to access for research. Legal purists may oppose it simply because caves are not specifically mentioned in the Wilderness Act. Finally, some conservationists fear that the wilderness label would ultimately destroy the cave it was meant to protect. Similar resistance usually arises with the consideration of any area for possible wilderness status.

The National Park Service (1974) and the U.S. Forest Service (1984) have stated that since caves are not specifically mentioned in the Wilderness Act they cannot qualify for admission to the National Wilderness Preservation System. There seems to be ample evidence to refute these arguments. Halliday (1971, p. 1) cites:

> . . .Robert W. Jasperson, general counsel of the Conservation Law Society of America -- in a widely circulated letter of January 5, 1967 -- pointed out that the concept of underground wilderness is wholly compatible with the Wilderness Act. He further noted that underground wilderness can properly be designated beneath surface areas devoted to extensive development.

IS THE CONCEPT OF UNDERGROUND WILDERNESS PRACTICAL?

It may be said that the people of the United States tend to love wild areas to death. Caves are no exception. Because of their sensitive ecosystems, channelized routes of travel, limited access points, and extremely long recovery times (if ever) caves present management problems often atypical of many surface wilderness areas.

There is a distinct risk to a resource in it being designated as a wilderness because of attention such designation attracts. As Graber (1976, p. 86) states:

> Publicity lures visitors; therefore, an end to publicity would have obvious value in stabilizing use. Designating a place as a park or wilderness area with no other change causes an immediate increase in its use.

This may not always occur as recently pointed out by McCool (1985) who feels there are more complex interactions occurring in the change of a use pattern than simple causal factors. He also found

that use patterns had actually dropped off in one area after it had been designated as a wilderness. These use trends need more study.

The advantage of formal wilderness status will be to give permanent protection to a cave. The resource manager will also be supported with a legal mandate to preserve and protect the resource. However, any area that is considered for wilderness designation must be inventoried. The Freedom of Information Act (P.L. 93-502, 1974) protects the public's right to know the information generated from such an inventory, including the locations of resources found within the area. Therefore, once a cave is studied for wilderness status, any protection that it had due to its generally unknown location could be lost. More recently district and regional managers have been given the use of more discretion in the release of sensitive information. It is possible that an exclusion from the Freedom of Information Act could be enacted for cave locations.

The public's inclination to visit wilderness, and the concomitant increased rate of damage, underscores a practical problem in the protection of cave wilderness. Due to limited points of entry, access to caves can often be controlled by the construction of substantial gates. However, gates are considered by some individuals to be an intrusion on their wilderness experience. While gates may stop illegal entry, they may also defy the intent of the Wilderness Act. However Section 4 (c) of the Act may allow the construction of a gate. This section essentially forbids the building of any structures in wilderness areas, except to meet minimum requirements for its administration. Therefore one can argue that a gate may be necessary on a cave entrance in order to control access, protect the cave ecosystem within, and preserve the wilderness quality of the cave. In addition, precedent has been set in many wilderness areas by the construction of such substantial structures as pack bridges. Of course, any gates constructed should allow unimpeded flow of all natural elements such as air, water, bats, and other species.

Hummel (1982) feels that there are other problems that inhibit the practicality of designating an underground wilderness. He makes note of instances of forces that oppose setting such a precedent, but his arguments are weak and easily refuted. First, there often is a lack of public support for such a designation. However, this has not stopped the eventual designation of many surface wilderness areas. Second, there have been attempts to include certain caves, which are truly unsuitable, into wilderness classification. He feels that such efforts have the effect of degrading the entire concept of wilderness. This is not a logical reason to exclude caves, which qualify, from the System. Third, the length of time to designate wilderness, ranging from 4 to 12 years, may wear down the energies of its supporters and allow more time for damage to occur. He feels that various administrative actions can protect the cave essentially overnight, but he fails to recognize that tracts that are being studied for wilderness designation are protected as if they were wilderness areas until a decision is made. Fourth, a wilderness study plan may contain release language which stipulates that the area cannot be reconsidered for this classification if it is once rejected. However, it may not contain such constraints. If an area is rejected as a legal wilderness, it can then be protected by local administrative actions. If the above arguments were valid as reasons for not proposing any areas as wilderness then there would be no legal wilderness areas in existence.

Hummel's arguments have been exemplified by the recent effort to have Cave Creek Cave in the Daniel Boone National Forest, Kentucky, selected as the first underground wilderness. The environmental, scientific, and sport caving communities are quite divided on the issue. The cave is not "untrammeled by man." Considerable attention has been brought on the cave, which apparently caused increased visitor use and concomitant impacts that further degraded the resource. However this has not been documented. There are additional difficulties created for proper management of this cave due to the private inholdings on the overlying surface and outstanding mineral rights.

Another important consideration for the protection of caves is the protection of the surface watershed over the cave system. Interviews with cave management professionals (Aley 1985; Hummel 1985; Kerbo 1985; Nieland 1985; Thornton 1985; Whitfield 1985) indicated unanimity of agreement that the surface over the cave must also be protected and preferably as wilderness. They opine that surface protection is mandatory to ensure the protection of the cave because of the complex interactions between surface land use and underground resources. These interactions can be illustrated by the intimate connections between surface water, soil water, and groundwater. Such protection is not easy or practical if the land above the cave is not of wilderness quality or if there are legal difficulties in implementation of the wilderness designation. If wilderness designation for a specific cave is slow, or where the designation may actually be detrimental to the resource, some alternatives may need to be applied.

ALTERNATIVES TO WILDERNESS DESIGNATION

It may not be readily realized that there are already cave wildernesses in the United States. Any cave in a national park is protected under the National Park Service Organic Act (P.L. 64-235, 1916), which states its purpose as follows:

> To conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Caves in existing surface wilderness areas are protected by law with the surface. Often it only remains to enlighten those in charge that because

of spatial coincidence with surface wilderness, caves can be fully protected by implementing concordant surface and underground management practices.

The immediate need for protection of some caves could be met by one or more management procedures with a workable management plan. This could apply while a particular cave is being studied for wilderness designation. However there is a danger that a local administrator could later remove the special management status or not enforce its intent. Therefore the management policies to be discussed are inherently less permanent and secure than would be actual wilderness designation.

The Federal Land Policy Management Act (P.L. 94-579, 1976) directs the Bureau of Land Management to study lands for eventual inclusion into the National Wilderness Preservation System. Hummel (1982) points out that caves can be protected in a wilderness-like manner by several management measures. First, they can be classified as Research Natural Areas, Outstanding Natural Areas, Primitive Areas, or Areas of Critical Environmental Concern. Such designations limit or restrict access and use of the pertaining area. Second, closure of lands is a temporary measure which limits access for a specified period of time. A third option is resource withdrawal from nonwilderness use. This is often done to restrict activities such as grazing and mining. These measures have the benefit of being able to be enacted quickly and locally; however, they are not a permanent or long-term solution.

In 1984 the Bureau of Land Management signed a working agreement with the Cave Research Foundation and the National Speleological Society to identify, study, and protect significant cave resources within their jurisdiction. This agreement is now being reviewed. The U.S. Forest Service has general protective policies which are similar to those of the BLM mentioned above, however, there is no standard working policy specifically intended for cave protection. A cave management policy is in the process of being formulated by the Forest Service.

CONCLUSIONS AND SUGGESTIONS

Caves qualify as wilderness both by measuring their values against contemporary wilderness values and by the letter and intent of the Wilderness Act of 1964. Many federally administered caves are already being managed as de facto wilderness areas. Other caves are de facto wilderness areas because they are largely unexplored and consequently remain pristine.

Even though there is some risk in creating a cave wilderness in that attention focused on it may actually destroy the resource, a wilderness designation of a cave of true wilderness quality should be attempted. Along with the designation, a management plan for protection and use of the cave and surface watershed must be drafted and enforced. Only by doing this will the viability of the concept be tested. Actual designation of an underground wilderness and ensuing protective management may prove quite practical and the most permanent method for long-term preservation of important cave resources.

REFERENCES

Aley, Tom. Director, Ozark Underground Laboratory. (Personal interview). February 16, 1985.

Culver, David C. Cave life: evolution and ecology. Cambridge, MA: Harvard University Press; 1982. 189 p.

The Conservation Foundation. Loving wilderness to death. In: Nash, Roderick, ed. The American environment. 2nd. ed. Reading, MA: Addison-Wesley; 1976: 265-276.

Davidson, Joseph K. Statement of Dr. Joseph K. Davidson, President of the Cave Research Foundation, at the meeting with the Mammoth Cave National Park Master Planning Team, Mammoth Cave National Park, Kentucky, May 25, 1968. Washington, DC: Cave Research Foundation; 1968; 5 p.

Davidson, Joseph K.; Bishop, William P. Wilderness resources in Mammoth Cave National Park: a regional approach. Columbus, OH: Cave Research Foundation; 1971, 34 p.

de Saussure, Raymond. Cave resources. In: Wilderness and recreation: a report on resources, values, and problems. ORRRC Report No. 3. Appendix B. Washington, D.C. Outdoor Recreation Resources Review Commission; 1962; 322-324.

Eastern Wilderness Act. Public Law 93-622. Act of Jan. 3, 1975. 88 Stat. 2096. 16 U.S.C. 1131 (note).

Federal Land Policy Management Act. Public Law 94-579. Act of Oct. 21, 1976. 90 Stat. 2744. 7, 16, 30, 40, 43 U.S.C.

Freedom of Information Act. Public Law 93-502. Act of Nov. 21, 1974. 88 Stat. 1561. 5 U.S.C. 552.

Glover, Jim. Journey to the underworld. National Parks 59(5&6): 22-27; 1985.

Graber, Linda H. Wilderness as sacred place. Washington, DC: Association of American Geographers; 1976. 124 p.

Halliday, William R. Underground wilderness potentials of Mammoth Cave, KY. Miscellaneous Series Bulletin No. 15. Seattle, WA: Western Speleological Survey; 1971. 7 p.

Hart, William J.; Boardman, Walter S. A wilderness plan for Mammoth Cave National Park and the surrounding region. Washington, DC: National Parks and Conservation Association; 1976; 16 p.

Hendee, John C.; Catton, William R., Jr.; Marlow, Larry D.; Brockman, Frank. Wilderness users in the Pacific Northwest - their characteristics, values, and management preferences. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1968. 92 p.

Hendee, John C.; Stankey, George H.; Lucas, Robert C. Wilderness management. Miscellaneous Publication No. 1365. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978; 381 p.

Hill, Carol. Cave minerals. Huntsville, AL: National Speleological Society; 1976. 137 p.

Hummel, J. B. Is the underground wilderness concept practical? In: National Cave Management Symposium Proceedings; 1980, October 14-17; Mammoth Cave National Park, Kentucky. Oregon City, OR: Pygmy Dwarf Press; 1982: 199-200.

Hummel, J. B. Bureau of Land Management. (Personal interview). February 16, 1985.

Huppert, George N. Cave conservation in the United States: a historical perspective and analysis. Greeley, CO: University of Northern Colorado; 1979. 179 p. D.A. dissertation.

Kerbo, Ron. National Park Service. (Personal interview). February 16, 1985.

McCool, Stephen F. Does wilderness designation lead to increased recreational use? Journal of Forestry. 83(1): 39-41; 1985.

Mohr, Charles E. The life of the cave. New York, NY: McGraw Hill; 1966, 232 p.

National Park Service, Mammoth Cave National Park. Draft environmental impact statement for the master plan and wilderness study for Mammoth Cave National Park. Mammoth Cave, KY: U.S. Department of the Interior, National Park Service; 1974, 194 p.

National Park Service Organic Act. Public Law 64-235. Act of Aug. 25, 1916. c. 408, 39 Stat. 535. 16 U.S.C. 1.

National Speleological Society. Guadalupe Escarpment wilderness. Huntsville, AL: National Speleological Society; 1970.

Nieland, James. U.S. Forest Service. (Personal interview). February 16, 1985.

Office of the Secretary of the Interior. [Letter to the President]. 1974 August 23. 1 leaf.

Office of the Secretary of the Interior. [Letter to Robert Stitt]. 1975 May 12. 3 leaves.

Poulson, Thomas L.; White, William B. The cave environment. Science. 165(3898): 971-981; 1969.

Rolston, Holmes, III. Valuing wildlands. Environmental Ethics. 7(1): 23-48; 1985.

Schmidt, Victor A. A wilderness proposal for Mammoth Cave National Park, Kentucky. Arlington, VA: National Speleological Society; 1967; 20 p.

Sides, Stanley D. Statement of Dr. Stanley D. Sides, President Cave Research Foundation for the public hearing regarding the wilderness proposal, Mammoth Cave National Park, Bowling Green, Kentucky, May 29, 1974. Lexington, KY: Cave Research Foundation; 1974; 4 p.

Smith, Philip M. The Flint Ridge Cave System: a wilderness opportunity. Washington, DC: Cave Research Foundation; 1961. 15 p.

Smith, Philip M.; Watson, Richard A. New wilderness boundaries. Environmental Ethics. 1(1); 61-64; 1979.

Stitt, Robert R. Law and sound policy require the National Park Service and the Secretary of the Interior to review the underground portions of Mammoth Cave National Park as to their suitability for wilderness under the Wilderness Act of 1964. Legal brief. Huntsville, AL: National Speleological Society; 1974 June 25. 26 p.

Stitt, Robert R.; Bishop, William P. Underground wilderness in the Guadalupe Escarpment: a concept applied. Bulletin of the National Speleological Society. 34(3): 77-88; 1972.

Straus, Lawrence. Caves: a paleoanthropological resource. World Archaeology. 10(3): 331-339; 1979.

Thornton, Jerry. Executive Director, American Cave Conservation Association. (Personal interview). February 16, 1985.

U.S. Forest Service, Daniel Boone National Forest. Draft environmental impact statement. Winchester, KY: U.S. Department of Agriculture, Forest Service; 1984. (not consecutively paged).

Watson, Patty Jo, editor. Archeology of the Mammoth Cave area. New York: Academic Press; 1974. 255 p.

Watson, Patty Jo. The prehistory of Salts Cave, Kentucky. Report of Investigations No. 16. Springfield, IL: Illinois State Museum; 1969; 86 p.

Watson, Richard, A. Statement on the proposed master plan for Mammoth Cave National Park, Kentucky, presented by Dr. Richard A. Watson, 28 May 1974. Washington, DC: National Parks and Conservation Association; 1974; 3 p.

Watson, Richard A. The preservation of wilderness karst in central Kentucky, U.S.A. Washington, DC: Cave Research Foundation; 1967; 12 p.

Watson, Richard A.; Smith, Philip M. Underground wilderness: a point of view. International Journal of Environmental Studies. 2: 217-220; 1971.

Weisbrod, Richard. Underground wilderness. Huntsville, AL: National Speleological Society; 1974. (unpaged).

White, William B. Caves: underground laboratories and underground wilderness. Earth and Mineral Sciences. University Park, PA: The Pennsylvania State University, College of Earth and Mineral Sciences; 46(2): 9-12; 1976.

Whitfield, Phil. British Columbia Provincial Parks. (Personal interview). February 16, 1985.

Wilderness Act. Public Law 88-577. Act of Sept. 3, 1964. 78 Stat. 890. 16 U.S.C. 1131 (note).

Zuber, Ronald E. A compendium of components relevant to cave resource management. Madison, WI: University of Wisconsin; 1977. 154 p. M.S. thesis.

Section 10. A Wilderness Planning-Application Example

APPLYING OUR KNOWLEDGE TO THE "BOB"

Robert C. Lucas

Proceedings Compiler

Steve McCool organized a special evening session at the National Wilderness Research Conference to present a case study involving the integrated application of a variety of advanced management concepts and techniques to the Bob Marshall Wilderness Complex, a large area including three contiguous wildernesses. The session involved eight presentations on different components of the total management program. A handout contained papers for each presentation, a reprinted paper, and an overview by McCool.

Because we think this was an unusually effective session that presented a practical program that could be borrowed from by other wilderness managers, we chose to print the handout material as the section that follows. The program described is also an encouraging example of cooperative teamwork among managers, scientists from the Forest Service, University, and an environmental research firm, and the concerned public.

PUTTING WILDERNESS RESEARCH AND TECHNOLOGY TO WORK
IN THE BOB MARSHALL WILDERNESS COMPLEX

Stephen F. McCool

The Bob Marshall, Great Bear, and Scapegoat Wildernesses, comprising a combined area of 1.5 million acres, lie astride the Continental Divide in northern Montana. While each was classified as Wilderness under different legislation, they are managed today as one coordinated unit, the Bob Marshall Wilderness Complex (BMWC) by the Flathead, Helena, Lewis and Clark, and Lolo National Forests. Together, they represent one of the largest undeveloped and pristine landscapes in the lower 48 States. They are home to a wide variety of wildlife; every major wildlife species present in the area at the time of European man's first entry is still present, although the grizzly bear and wolf are on the threatened and endangered species list.

The "Bob," as many local individuals term the area, is often recognized as the "flagship" of America's National Wilderness Preservation System. What happens in the area is often of great interest not only to people in local communities but to others across the Nation and around the world. To many, the area represents the essence of wilderness values and purposes.

The BMWC has long provided outstanding opportunities for extended horse and backpacking trips; it is nationally famous for fall big game hunting, and provides excellent opportunities for river floating through 86 miles of the Flathead River now a part of the National Wild and Scenic Rivers System. While use densities in the BMWC are relatively low, visitor research has shown that visitors are concerned about encounters with others and about conflicts with other types of users.

A management plan for the area was developed in 1972. However, because of the lack of public support, most of the plan has never been implemented. In 1982, a process was begun to develop a new plan, with several different assumptions about the nature of the planning process. Effective wilderness planning was viewed as possible only with (1) use of contemporary wilderness management concepts and technology and (2) consensus of those affected by the plan.

In 1981, a decision was made to base the planning process on the Limits of Acceptable Change wilderness planning system. A draft section of the Forest Service Manual had been released in the fall which described the process, although the system itself wasn't completed until January 1985. In early 1982, another decision was made to incorporate public involvement from the beginning, and an initial meeting of the LAC Task Force was held in February. This summary describes both the LAC process and the important role of the Task Force in developing the new visitor use management plan.

It is important to understand that the success of the planning effort in the BMWC is highly dependent on the interaction of these two elements. LAC will not succeed in this area without continuing public participation. On the other hand, the public participation is successful partly because of the structure LAC provides to the planning process. Another element critical to the success of the planning was the commitment made by the managers, members of the public, and researchers to do what they could to make the system work in the face of decreasing budgets. Undoubtedly, the importance of the BMWC as a symbol of wilderness preservation helped with securing this level of commitment.

The purpose of this report is to summarize the various elements of application of LAC to the BMWC as well as describe the public participation process. The objective in doing this is to inform others how wilderness management planning was approached in this situation, not to describe how wilderness management planning should be conducted.

The report is organized in two sections. The first section describes the LAC process, and how various technical and research efforts were used within the context of that process. A reprint of a Western Wildlands article describing the LAC system opens this part of the discussion. In the second section, the public involvement process is depicted, as well as the role of the public in developing and implementing the plan.

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Scapegoat Mountain, Bob Marshall Wilderness Complex. *Photo/Dan Dodge*

Limits of Acceptable Change: A New Framework for Managing the Bob Marshall Wilderness Complex

George H. Stankey, Stephen F. McCool and Gerald L. Stokes

The Bob Marshall Wilderness has been aptly described as the "flagship" of the American wilderness preservation system. Along with the adjacent Great Bear and Scapegoat Wildernesses, the "Bob," as it is known locally, forms the core of a 1.6 million acre block of spectacular wild country. From the awesome Chinese Wall to the grizzly bear that roam throughout the area, the Bob Marshall Wilderness Complex (BMWC) possesses much of what we commonly ascribe to wilderness. And each year thousands of visitors come to the area to backpack, white water raft, or hunt big game. The BMWC is truly a national treasure.

But those values and features that give the BMWC its special place in America's wilderness system are threatened. Managers, users, citizens and scientists all have expressed concern that increasing demands on the Complex could damage the area's vegetation, soil, water and wildlife; moreover, the growing numbers of users make it increasingly difficult to provide the kinds of outstanding opportunities for solitude described in the 1964 Wilderness Act.

In addition to increasing use pressure on

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Picture Ridge from Picture Peak, Bob Marshall Wilderness. *Photo/Don Dodge*

the BMWC, changing legislative guidelines also demand that managers move to resolve the issue of "How much is too much?" For example, regulations implementing the National Forest Management Act require national forest plans to "provide for limiting and distributing visitor use of specific portions in accord with periodic estimates of the maximum levels of use that allow natural processes to operate freely and that do not impair the values for which wilderness areas were created."

But while the pressures confronting the BMWC are severe, they are by no means unique. Many wildernesses today throughout the country face similar problems, and managers, interested citizens and others are working on means to implement effective management to protect the environmental and experiential qualities that characterize wilderness.

The carrying capacity approach to wilderness management, drawn from range and wildlife management, holds an appealing simplicity. If some specific use level actually signals the onset of environmental deterioration and unsatisfactory recreational experiences, it could be said that an area is exceeding its carrying capacity when it exceeds that level. Wilderness managers would have a clear, unequivocal basis for restricting use.

Considerable research has been done on the carrying capacity model and its ability to help provide managers with the information necessary to make decisions about appropriate use levels. Both ecological and social studies focused on the level of use at which unacceptable impacts begin. However, this focus was hampered by the lack of a clear and predictable relationship between use and impact. In some environmental settings, even low use levels can produce substantial impacts on vegetation and soils; in other locations, such resources are very resilient. Some recreational experiences, such as the search for solitude, are adversely affected by increased use levels; others, such as physical exercise, are not.

Developing a straightforward understanding of the use-impact relationship was also confounded by what we might call the "it all depends" syndrome. A certain amount of use in a particular environmental setting would lead to a certain level of impact, depending on the weather or on the specific kind of recreational use taking place. A certain number of encounters per day would provoke a particular reaction from people, depending on where the encounters occurred or how the people behaved. The virtually infinite number of factors upon which the use-impact relationship depended makes it very difficult to arrive at answers that could be used by managers.

However, the basic difficulty grew out of the focus on "How much is too much?" Increasingly, researchers and managers came to realize that this was the wrong question. Rather than attempting to discover this elusive number, it became apparent that attention should be focused on what kinds of conditions were desired. Conditions included the state of the resource—the quality of vegetation at campsites or forage in meadows, water quality and other measures, as well as the nature of the experience—the encounters with others while traveling or at the campsite, for example. By focusing on the conditions desired, we could then begin to look at how much and what kinds of use would be consistent with their maintenance.

This shift in attention from an appropriate use level to the desired condition underlies our revised approach to the recreational carrying capacity issue.

This approach—the limits of acceptable change (LAC)—represents a framework within which decisions can be made about the kinds of conditions that will be permitted to occur in an area. We will also look at how the LAC framework has been used to address recreation impacts and issues in the BMWC and how it integrates with the political environment within which decisions about wilderness resources are made.

The basic premise of the LAC concept is that change is a natural, inevitable consequence of recreation use. Both environmental and social changes are involved. Acceptance of this premise immediately redefines the traditional question about carrying capacity from "How much use is too much?" to "How much change is acceptable?"

The LAC framework recognizes the inevitable impacts that occur as a result of human use. Wilderness managers might want to retain pristine conditions throughout an area, but the reality is that once use occurs, resource conditions begin to change—soils are compacted, vegetation is disturbed. Similarly, social conditions change—interparty contacts rise, conflicts increase. The nature and extent of these changes will vary throughout an area because of differences in types and amount of use, susceptibility of vegetation and soils to use pressure and other factors. This does not imply that a decision could not be made to prohibit change caused by recreation; such a decision would, however, necessitate a virtual prohibition of recreational use.

The shift in focus from "how much use" to "how much change" carries with it two important implications. First, it directs attention from use level as the key management concern to the environmental and social conditions desired in wilderness. The link between use level and conditions is complex; moreover, the previous focus on use level only partially explained and helped manage human-induced change. The new orientation focuses directly on managing for desired conditions rather than on how recreation use *per se* should be managed.

The second implication of the LAC management framework is that it clearly places the issue of capacity in a prescriptive as opposed to a technical context. Tradi-

tionally, the task was to define the level of use beyond which excessive impact would occur. Such an approach contributed to the belief that establishing capacity was a technical procedure requiring an understanding of the relationship between use and change. However, the LAC framework, with its focus on desired conditions, immediately addresses the matter of *acceptable change*, and the answer to such a question is ultimately one of personal judgment, not science. Judgements of acceptability require not only the viewpoints of managers and researchers but of citizens as well.

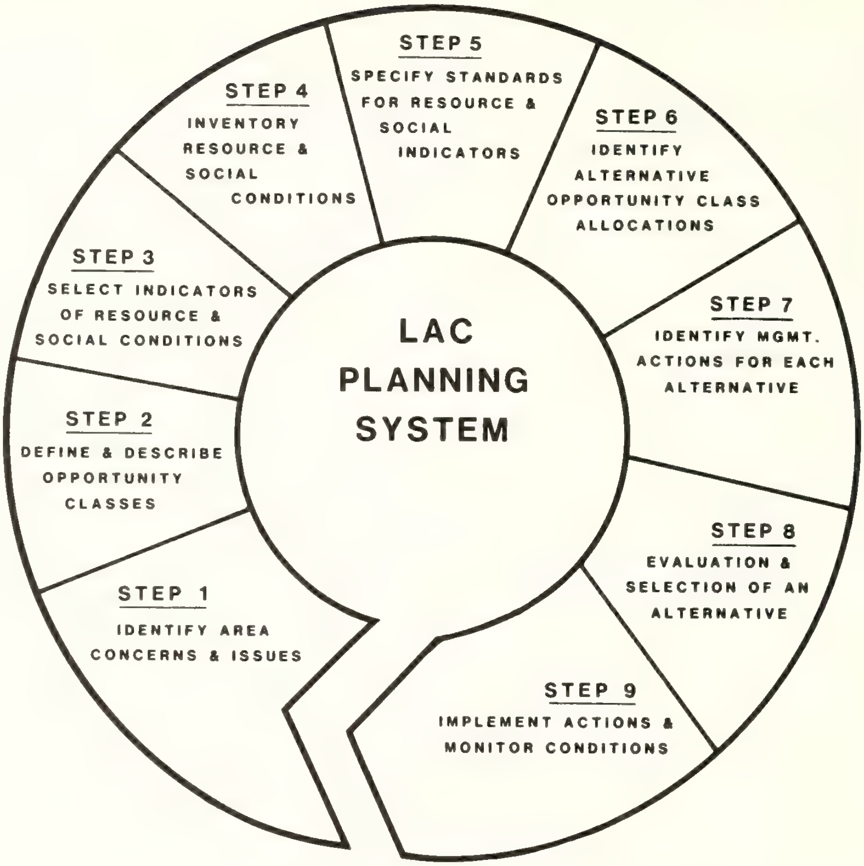
Of course, technical information and understanding remain an important part of the LAC process. It is critical that we understand the technical processes of energy flow in wilderness ecosystems and the complex relationships between recreational use and vegetative impact. However, the LAC process treats such information as an aid in answering what is acceptable, not as a determinant.

Explicit recognition of the importance of providing diverse wilderness conditions in the BMWC and the implementation of management actions to achieve or maintain conditions form the basis of the LAC framework. Given that any use produces at least some change, the process requires managers to identify where, and to what extent, varying degrees of change are appropriate and acceptable. The conditions that characterize a particular type of opportunity and that distinguish it from others are specified by measurable objectives that define the limits of acceptable change (Lime 1970, Frissell and Stankey 1972).

We talk about "acceptable" change. The word "acceptable" has been purposely selected because it emphasizes the idea that the amount of change that occurs reflects a judgement made about its appropriateness. Other words might have been chosen, such as "unavoidable." A word like "unavoidable" implies there is a discrete predictable amount of change associated with a given use level, beyond which no further change should occur. However, this is simply not an accurate portrayal of the way things work.

To implement the LAC framework, managers proceed through nine interrelated steps (Figure 1). Briefly, these steps involve the following:

Figure 1



1) Identify area issues and concerns. Citizens and managers meet to identify what special features or qualities within the area require attention, what management problems or concerns have to be dealt with, what issues the public considers important in the area's management, and what role the area plays in both a regional and national context. This step encourages a better understanding of the wilderness resource, a general concept of how the resource should be managed and a focus on principal management issues. Issues such as outfitter allocation, horse and trail management, threatened and endangered species and opportunities for solitude were identified as important in the BMWC.

2) Define and describe wilderness recreation opportunity classes. Any wilderness area contains a diversity of physical-biological features, use levels, evidence of recreation and other human uses, and type of wilderness experiences. The type of management needed will also vary throughout an area. Opportunity classes describe subdivisions or zones of wilderness where different resource, social and managerial conditions will be maintained. These classes represent a way of defining a range of diverse conditions within the wilderness. And while diversity is the objective here, it is important to point out that the conditions found in all cases must be consistent with the area's designation as wilderness. The definition of opportunity classes is not an excuse to maintain conditions inappropriate in a wilderness.

In step 2, we define the number of classes that will be managed and develop general descriptions of the kinds of resource, social, and managerial conditions appropriate to each. For example, Table 1 shows the resource and social settings identified as appropriate in each of four opportunity classes in the BMWC, ranging from pristine conditions to one typified by the relatively more visible impacts of human use. Again, such classes serve as management objectives for specific areas of the wilderness.

3) Select indicators of resource and social conditions. Indicators are specific elements of the resource and social setting selected to represent (or to be "indicative of") the conditions deemed appropriate and acceptable in each opportunity class. Because it is impossible to measure the condition of and change in every resource and social feature in a wilderness, we select a few indicators as measures of the overall condition or "health" of the area. Examples would include amount of bare ground at campsites or average number of other groups encountered per day. They should be easy to measure quantitatively, related to

Table 1
Brief Descriptions of Wilderness Recreation Opportunity Classes in LAC Planning for the Bob Marshall Complex

	MOST PRISTINE			LEAST PRISTINE
	Opportunity Class I	Opportunity Class II	Opportunity Class III	Opportunity Class IV
RESOURCE SETTING: (General description)	Unmodified natural environment	Unmodified natural environment	Unmodified natural environment	Predominantly unmodified natural environment
Ecological conditions	Not measurably affected by the action of users	Minimally affected by the action of users	Moderately affected by the action of users	Many locations substantially affected by the action of users
Prevalence and duration of impact	Temporary loss of vegetation where camping occurs and along some travel routes. Typically recovers on an annual basis.	Minor loss of vegetation where camping occurs and along most travel routes. Most impacts recover on an annual basis.	Moderate loss of vegetation where camping occurs and along most travel routes. Impacts in some areas persist from year to year.	Moderate loss of vegetation and soil on major travel routes campsites, and popular lakeshores. Impacts persist from year to year.
Visibility of impacts	Not apparent to most visitors	Apparent to only a low number of visitors	Apparent to a moderate number of visitors	Impacts are readily apparent to most visitors
SOCIAL SETTING: (General description)	Outstanding opportunity for isolation and solitude	High opportunity for isolation and solitude	Moderate opportunities for isolation and solitude	Moderate to low opportunities for isolation and solitude
General level of encounters	Very infrequent	Low	Moderate	Moderate-high
Interparty contacts while traveling	Very few	Low	Moderately frequent	Relatively high
Interparty contacts at the campsite	Nonexistent	Fairly low	Moderately frequent	Common

the conditions specified by the opportunity classes and reflect changes in recreation use.

Indicators are an important part of the LAC process because their condition reflects the overall conditions found throughout an opportunity class. It is important to understand that an individual indicator might not adequately depict the condition of a particular area. It is the "bundle" of indicators that is used to monitor an area.

4) Inventory existing resource and social conditions. Inventories can be a time-consuming and expensive part of planning. In the LAC framework, the inventory is guided by the indicators selected in step 3. Other factors, such as bridges, lookout towers, outfitter base camps and critical habitat, can also be inventoried. This information will be helpful later when the consequences of various alternatives are being evaluated. The inventory data are mapped so that both the condition and location of the indicators are known. The inventory provides a measure of the indicators' existing condition throughout the area, as well as a data base from which managers can formulate the standards for each indicator in each opportunity class.

5) Specify standards for resource and social conditions in each opportunity class. Here we identify the range of conditions for each indicator considered appropriate and acceptable for each opportunity class. By defining those conditions in measurable terms, we provide the basis for establishing a distinctive, diverse range of wilderness opportunities. Standards serve to define the "limits of acceptable change." They are the maximum permissible conditions that will be allowed in a specific opportunity class; they are not necessarily objectives. In the BMWC, for example, where four opportunity classes have been defined, standards for campsite solitude and other indicators have been proposed.

The inventory data collected in step 4 play an important role in setting standards. We want the standards defining the range of acceptable conditions in each opportunity class to be realistic and attainable; we also want them to do more than mimic existing conditions. Standards play a critical role of indicating when restoration or enhancement might be needed.

6) Identify alternative opportunity class allocations reflecting area-wide issues and concerns and existing resource and social conditions. Most wildernesses could be managed in several different ways and still retain their basic wilderness qualities. In step 6, we begin to identify some of these different alternatives. Using information from step 1 (area issues and concerns) and step 4 (inventory of existing conditions), managers and citizens can begin to explore how well different opportunity class allocations meet varying interests, concerns and values. For example, in the BMWC planning effort, one alternative allocated a large proportion of the area to those opportunity classes in which impact is least acceptable. However, another alternative gives greater emphasis to those opportunity classes where higher impact levels are acceptable. Yet another alternative featured maintenance of the *status quo*.

7) Identify management actions for each alternative. The alternative allocations proposed in step 6 are only the first step in the process of developing a preferred alternative. In addition to the kinds of conditions

that would be achieved, both managers and citizens need to know what management actions will be needed to achieve the desired conditions. In a sense, step 7 requires an analysis of the costs, broadly defined, that will be imposed by each alternative. For example, many people might find attractive an alternative that calls for restoration of much of the area to a pristine character. However, such an alternative might necessitate introduction of strict use rationing, prohibition of horses and closure of some areas. In light of such costs, the alternative might not seem as attractive.

Step 7 provides a measure of what it will take to move the area from its existing condition to that desired. Management actions for the BMWC include information, education, campsite closure and rehabilitation, increased enforcement of regulations and some restrictions on party size. The action proposed for a specific area varies according to the opportunity class and intensity of the problem.

8) Evaluation and selection of a preferred alternative. With the various costs and benefits before them, citizens and managers can proceed to evaluate the various alternatives, and the managing authority will then select a preferred alternative. Evaluation must take many factors into consideration, but examples would include the responsiveness of each alternative to the issues and concerns indentified in step 1 and the management requirements identified in step 7. It is important that the factors figuring into the evaluation process and their relative importance be made explicit and available for public review.

9) Implement actions and monitor conditions. With an alternative finally selected, the necessary management actions (if any) are put into effect and a monitoring program instituted. The monitoring program focuses on the indicators selected in step 3 and compares their condition with those identified in the standards. This information reflects the success of the actions. If conditions are not improving, the intensity of the management effort might need to be increased or new actions implemented.

These nine steps comprise the LAC framework. By identifying desired conditions in a precise, measurable way, the LAC system would avoid the lack of specificity and "motherhood" nature of many previous management plans. But the LAC is, in many ways, still theory or at least an untested and unproven approach. Will it really work?

The verdict is not in and might not be for some time. The application of the LAC framework in the three wildernesses comprising the BMWC represents the first complete test of the system. The effort involves the four national forests that manage the area (Flathead, Helena, Lewis and Clark and Lolo), the Wilderness Management Research Unit of the Intermountain Forest and Range Experiment Station and a wide range of wilderness interest groups.

Because of the area's size and complexity, as well as the intense public interest in its management, it has been necessary to develop some special approaches to help guide application of the LAC. Many of the ongoing duties involved with working through the process have been placed in the hands of a contracted consultant who acts as a facilitator, thus freeing national forest staff from many of the logistical details involved in developing proposed management actions for such a large area. The facilitator also acts as a neutral party in the process in an attempt to bring public interest groups into the early steps of the LAC process. Because many of these groups ultimately will be affected by the results of the process, they have been encouraged to provide their experience and knowledge in the effort to develop a preferred alternative.

Managers still play a key role as members of a core team that meets periodically to discuss details of the process, information needs and the commitment of organizational resources. The facilitator identifies responsibilities for these individuals as well as decisions for which they are ultimately responsible.

In addition to the core team, a larger task force also has been established. The task force is composed of researchers, Forest Service personnel and individuals representing organized and unorganized interests in the Bob Marshall Complex. The task force was organized in this way to encourage dialogue and mutual learning (Friedman 1973) among individuals with different types of expertise.

The task force provides continuing public participation in the LAC process. It is a means of informing citizens about the process and gaining their understanding and support. A basic precept underlying formation of the task force is that a substantial, important body of expertise exists within the citizenry. Another precept is that without public understanding and support, the process is unlikely to succeed. This is a particularly important notion, for it is consistent with the growing realization that resource planning is ultimately a political rather than a technical process. Although managers' technical skills are clearly needed, they must be coupled with a level of political competence that insures understanding of the various interest groups and their beliefs, values and motives (Cortner and Richards 1983). Such understanding helps managers negotiate planning direction so that the various interests are dealt with in a reasonable and responsible fashion. By being responsive to the expertise and concerns of various interest groups, planning has a better chance of success (Culhane and Friesema 1979). Finally, the task force represents a microcosm of the political marketplace. The diversity of interest groups represented insures that all values and viewpoints will be addressed in the planning process. The "ownership" felt by individuals working cooperatively should also ensure that the plan is implemented.

There has been much frustration with wilderness planning in the past, and the shelves are filled with documents that never saw the light of day. Will the LAC framework change this or is a similar fate in store? Obviously, we will have to wait and see. However, the integral role of public participation in developing the LAC process, coupled with the specificity of the conditions that managers and citizens identify as desirable, should help provide a level of accountability often lacking in past plans.

For those interested in the details of the LAC process, an expanded version of this article will soon be available as a General Technical Report entitled The Limits of Acceptable Change System for Wilderness Planning. *Copies can be obtained from the Intermountain Forest and Range Experiment Station, 507 25th St., Odgen, Utah, 84401.*

LITERATURE CITED

CORTNER, H. J. AND M. R. RICHARDS. 1983. The Political Component of National Forest Planning. Journal of Soil and Water Conservation. 38:79-81.

CULHANE, P. J. AND H. P. FRIESEMA. 1978. Land Use Planning for the Public Lands. Natural Resource Journal 19:43-74.

FRIEDMANN, JOHN. Retracking America. 1973. Anchor Press/Doubleday, Garden City, New York. 289 pages.

FRISSELL, S. S. AND G. H. STANKEY. 1972. Wilderness Environmental Quality: Search for Social and Ecological Harmony. *In:* Proceedings, Society of American Foresters' Annual Meeting. Hot Springs, Arkansas. Pages 170-183.

LIME, D. W. 1970. Research for Determining Use Capacities of the Boundary Waters Canoe Area. Naturalist 21:8-13.

CAMPSITE INVENTORY

David N. Cole

As discussed previously, the crux of the Limits of Acceptable Change (LAC) system is the periodic monitoring of key indicators to determine whether or not standards are being met. One of the most difficult steps in implementing LAC is the selection of indicators that are meaningful and that can be monitored in a cost-effective manner. There is little value in selecting indicators that cannot be adequately monitored, whether this inability is due to constraints on manpower, funding, equipment, or training. There is also little value in collecting data on trivial indicators that bear little relation to the area's most significant objectives and problems.

For the Bob Marshall Wilderness Complex, an early meeting of the Task Force identified campsite impacts as one of the foremost concerns. Consequently, development of a procedure for inventorying and monitoring campsites was a high priority. Such a procedure would be the basis for evaluating indicators developed to measure the number and condition of campsites. Because the area to be inventoried was 1.5 million acres in size and there were only a handful of people available to work part-time on the inventory, a procedure involving rapid estimates of a number of site characteristics and impact parameters was developed. Such systems are becoming increasingly common, particularly in areas where large numbers of campsites must be inventoried. Although not as precise as systems based on measurements, rapid estimate systems provide gross estimates of site condition and are often the only feasible option. For example, in Sequoia and Kings Canyon National Parks, where one of the earliest of such systems was developed, over 7,400 campsites have been inventoried (Parsons and MacLeod 1980). It would be virtually impossible to take detailed measurements of so many sites.

The procedure developed for the Bob Marshall Wilderness Complex was a modification of the Sequoia-Kings Canyon system and is explained in more detail in Cole (1983a). The form that was used is shown at the end of this article. The general procedure was to locate all sites in the area--not just those that were most heavily used or damaged. All likely campsite locations were visited and a form was filled out for each site showing evidence of previous recreational use. The usual criterion for deciding whether or not a site is a campsite is evidence of a campfire. Inventorying all sites is important if management is concerned about proliferation of new sites or shifts in the distribution of sites.

A considerable amount of information not directly related to the LAC process was collected on each site. For example, the front side of the form consists of a series of parameters that describe the site's location, size, and facilities. This information was collected because it is potentially useful and only requires a few minutes to fill out. Most of the time required to inventory campsites is spent travelling between sites. Therefore, the cost of collecting a little more information is low.

The data collected on indicators are on the back side of the form. For each site, information was collected on the following parameters: vegetation loss, increase in bare mineral soil, tree damage, tree root exposure, development, cleaniness, camp area, barren core camp area, and number of social trails. Weighted ratings for each parameter were then summed to derive an overall index of impact for each site.

Indicators were selected following field trips to identify problem situations, evaluation of public concerns, and analysis of detailed measurements taken on a sample of 35 campsites (Cole 1983b). Frequent problems in need of management were places with excessive numbers of sites, places with large numbers of highly impacted sites, and individual sites with either excessive amounts of tree damage or excessive amounts of barren soil. The indicators selected to address these problems were (1) number of campsites per 640-acre section, (2) number of moderately and highly impacted campsites per 640-acre section (moderately and highly impacted campsites are those with weighted impact indexes of 30-50 and over 50, respectively), (3) number of damaged trees on any campsite, and (4) area of barren core on any campsite.

From the inventory data collected it was possible to display the range and distribution of conditions for each indicator. For indicators 3 and 4, this was available directly from the inventory form. To evaluate indicators 1 and 2, all campsites were located on maps along with their impact index. It was then possible to count the number of campsites and the number of moderately and highly impacted campsites in each section. For example, the number of highly impacted

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campsites per section ranged from 0 to 5, with the vast majority of sections having either 0 or 1 highly impacted site. Knowledge of these distributions, along with considerations of objectives, facilitated the selection of standards for each indicator. Because there were four opportunity types, most indicators had four different standards, one for each opportunity type. For example, the maximum number of campsites allowed per section is 1 in opportunity class I, 2 in class II, 3 in class III, and 6 in class IV; the maximum amount of barren core on any campsite ranged from 100 square feet in class I to 2000 square feet in class IV.

Once a preferred allocation of opportunity classes was agreed upon, it was possible to identify places where these standards were exceeded. By counting the number of places where standards were exceeded it was possible to evaluate how realistic the standards were. For example, 82 campsites exceeded the barren core area standard. This was judged to be a reasonable number of situations to try to correct and these standards were accepted. Once the final set of standards and the opportunity class allocation is accepted, the places where standards are exceeded are identified as "problem areas" in need of management. Actions are taken to correct these problems and then, at a future date, sites are reexamined--the monitoring phase--to see where old problems have been solved and new problems have developed.

REFERENCES

Cole, David N. Monitoring the condition of wilderness campsites. Research Paper INT-302. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983a. 10 p.

Cole, David N. Campsite conditions in the Bob Marshall Wilderness, Montana. Research Paper INT-312. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983b. 18 p.

Parsons, David J.; MacLeod, Susan A. Measuring impacts of wilderness use. Parks. 5(3): 8-12.

BOB MARSHALL - GREAT BEAR - SCAPEGOAT WILDERNESS COMPLEX - CAMPSITE INVENTORY

GENERAL SITE DESCRIPTION

(1) SITE NUMBER: ______________

(2) UTM COORDINATES: 12 _ _ _ _ E _ _ _ _ _ _ N

(3) USGS QUADRANGLE: ________________________

(4) DATE CODED: _ _ (Month) _ _ (Day) _ _ _ _ (Year)

(5) CODED BY: (Name) ________________________

(6) ELEVATION: (To nearest 100 ft) ___________

(7) VEGETATION: (Circle one)

1 - Closed forest   3 - Nonforested, densely vegetated

2 - Open forest   4 - Nonforested, sparsely vegetated

Dominant species ___________________________
Habitat type, if known _____________________

(8) LANDFORM: (Circle one)

1 - Floodplain   2 - Other valley bottom   3 - Cirque basin

4 - Sideslope   5 - Ridgetop   6 - Other ______________

(Do in office)
(9) DISTANCE TO CLOSEST TRAILHEAD: ____________________(miles)

(10) DISTANCE TO CONSTRUCTED TRAIL: ___________________(feet)

Screening: 1 - Complete   Maintained: 1 - Yes
(circle one) 2 - Partial   (circle one) 2 - No
3 - None

(11) DISTANCE TO WATER: ______________________________(feet)

Type: 1 - River/creek   3 - Spring
2 - Lake   4 - Other ____________

(12) DISTANCE TO CLOSEST CAMPSITE: __________________(feet)

Screening: 1 - Complete
(circle one) 2 - Partial
3 - None

(Do in office)
(13) NUMBER OF OTHER CAMPSITES WITHIN 1/4 MILE: ___________

(14) MAXIMUM PARTY SIZE ACCOMMODATED: (Circle one)

1 - 1-2   3 - 7-10   5 - more than 15

2 - 3-6   4 - 11-15

(15) TYPE OF USE: (Circle as many as apply)

1 - Foot   3 - River

2 - Stock   4 - Outfitter

(16) CLOSEST FIREWOOD SOURCE: (Circle one)

1 - One-site   3 - 100-300 feet   5 - >1/4 mile

2 - <100 feet   4 - 300 ft-1/4 mile

(17) CLOSEST FORAGE SUPPLY: (Circle one)

1 - On-site   3 - 100-300 feet   5 - >1/4 mile

2 - < 100 feet   4 - 300 ft-1/4 mile

(18) FACILITIES: Present ____ Absent ____
(If present, write number of each type in blank.)

1 - Fire ring ____   6 - Hitchrail _____
2 - Primitive seat _____   7 - Corral _____
3 - Constructed seat _____   8 - Toilet _____
4 - Table/shelf/counter _____   9 - Other _____
5 - Meat rack _____

IMPACT EVALUATION	ON CAMPSITE	ON UNUSED COMPARATIVE AREA
(19) VEGETATION COVER: (Be sure to compare similar areas, same species, slope, rockiness, and canopy cover)	1 - 0-5% 3 - 26-50% 5 - 76-100% 2 - 6-25% 4 - 51-75%	1 - 0-5% 3 - 26-50% 5 - 76-100% 2 - 6-25% 4 - 51-75%
(20) MINERAL SOIL EXPOSURE: (Percent of area that is bare mineral soil)	1 - 0-5% 3 - 26-50% 5 - 76-100% 2 - 6-25% 4 - 51-75%	1 - 0-5% 3 - 26-50% 5 - 76-100% 2 - 6-25% 4 - 51-75%

	Rating (Circle one category) 1	2	3	Calculation of impact index (do in office)
(21) VEGETATION LOSS:	(no difference in coverage)	(Difference one coverage class	(Difference two or more coverage classes)	
(22) MINERAL SOIL INCREASE:	(No difference in coverage)	(Difference one coverage class)	(Difference two or more coverage classes)	
(23) TREE DAMAGE: No. of trees scarred or felled_____ % of trees scarred or felled______ (est.)	(No more than broken lower branches)	(1-8 scarred trees, or 1-3 badly scarred or felled)	(> 8 scarred trees, or >3 badly scarred or felled)	
(24) ROOT EXPOSURE: No. of trees with roots exposed____(est.) % of trees with roots exposed______	(None)	(1-6 trees with roots exposed)	(> 6 trees with roots exposed)	
(25) DEVELOPMENT:	(None)	(1 fire ring with or without primitive log seat)	(> 1 fire ring or other major development)	
(26) CLEANLINESS: No. of fire scars______	(No more than scattered charcoal from 1 fire ring)	(Remnants of >1 fire ring, some litter or manure)	(Human waste, much litter or manure)	
(27) SOCIAL TRAILS: No. of trails_____	(No more than 1 discernible trail)	(2-3 discernible, max. 1 well-worn	(> 3 discernible or more than 1 well-worn)	
(28) CAMP AREA Estimated area______ (ft^2)	(< 500 ft^2)	(500-2000ft^2)	(> 2000 ft^2)	
(29) BARREN CORE CAMP AREA: Estimated area______(ft^2)	(< 50 ft^2)	(50-500 ft^2)	(> 500 ft^2)	

(30) PHOTO RECORD________________________

(31) COMMENTS: (Details about location of site, impacts, management suggestions, etc.)

____

____

____

(32) IMPACT INDEX __________

VISITOR TREND SURVEY DATA IN RELATION TO THE LAC PROCESS

Robert C. Lucas

Comparable visitor surveys covering a wide range of activity, experience, attitude, and visitor characteristics were carried out in the three-area Bob Marshall Wilderness complex in 1970 (Lucas 1980) and 1982 (Lucas 1985). Although the studies were not designed or conducted with Limits of Acceptable Change (LAC) in mind, information from them has proved useful in the LAC process, particularly in choosing indicators and setting standards, as well as describing general issues.

The availability of data from two periods has increased the usefulness of the survey data. Various conditions are not only described for a recent year (1982), but, because of data for the earlier year (1970), it is apparent whether potential problems associated with the condition are improving, stable, or deteriorating. The trend information suggests priority of managerial attention, the need to represent the condition with an indicator, the needed level for standards, and the magnitude of the needed management effort beyond what 1-year data could.

Some general background information was relevant to the overall LAC process, helping identify issues. Overall visitor satisfaction stayed high, and satisfying factors changed little from 1970 to 1982. However, dissatisfying factors changed substantially. Complaints about trail conditions increased six-fold, and complaints about crowding and conflict (particularly hikers' dislike of horse use and its impacts) tripled.

Hiker use increased much more than horse use in the 12-year period, stays became a little shorter and parties smaller. Visitors were less dependent on wood campfires and used stoves more. Use was less concentrated. These trends generally suggest lower potential impacts per party.

Compared to 1970, most experienced visitors in 1982 felt overall area quality had stabilized; in 1970 many more of the experienced visitors felt the area's condition was deteriorating. The management challenge faced in the LAC process seems to be more preventing further deterioration than restoration.

Other results related more specifically to indicators and standards. These are presented in outline form, relating study data to the importance of potential indicators and the current situation in the Bob Marshall Wilderness complex relative to the indicators.

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1. Campsite Density/Isolation

   a. Importance

   --Most campers want isolation (table 1).

Table 1.--Camper preferences for camps nearby, Bob Marshall Wilderness complex, 1970 and 1982

	Number of other nearby camps desired			
Year	0	1	2	3 or more
1970	86	7	4	3
1982	81	7	6	6

--Standards for campsite solitude need to be fairly strict, although 1982 campers accept other campers a little more than in 1970.

--Also, solitude ranked number five on a list of appeals in 1982, number 4 in 1970, and the higher ranked appeals are things largely beyond managers' control; for example, scenery.

--The Wilderness Act requires "outstanding opportunities for solitude," and "impact of man's work substantially unnoticeable."

   b. Situation:

--Campers report more trouble finding desired level of campsite solitude (table 2).

Table 2.--Camper reports of success in finding desired campsite solitude, Bob Marshall Wilderness complex, 1970 and 1982

	Success in finding desired campsite solitude		
Year	Every night	Some nights	Never
	- - Percentage of total visits - -		
1970	76	18	6
1982	63	33	4

--Lenient standards for campsite solitude will probably lead to increased problems finding desired solitude. (Very few campers may have wanted some neighbors but didn't have them.)

--92 percent of campers reported "no trouble" finding an unoccupied campsite in 1982 (not asked in 1970). Only 2 percent reported trouble at more than one place. Supply of campsites appears adequate.

2. Campsite Impacts

a. Importance:

--80 percent considered but rejected campsites.

--26 percent rejected sites because of condition--reasons, in order, firewood scarce (4 percent); grazing scarce (3 percent); bare ground (3 percent); litter (2 percent); horse manure (2 percent). (Only two people mentioned "old firerings.")

--The Wilderness Act requires "preservation of wilderness character". . . "unimpared," "preservation of natural conditions," "with imprint of man's work substantially unnoticeable."

b. Situation:

--In 1970, 22 percent rated vegetation and soil impact conditions only "fair to poor."

--In 1982, 31 percent said "fair to poor." ("Very good" ratings dropped from 47 percent to 33 percent.)

--Situation worsening in view of campers; standards probably should be set to stop decline, perhaps reverse trend.

3. Number of Encounters

a. Importance:

--Only 11 or 12 percent (both years) said "number (of other visitors) met didn't matter." Important to almost 90 percent.

--49 percent in 1982 said solitude a "very important" reason for visiting wilderness. (Scenery, relaxation, escape civilization, and avoid mechanized recreation were higher, but managers have little control of these.) (Not asked in same way in 1970.)

--Satisfaction was higher when encounters lower, and fewer said they met "too many" at lower encounter levels--especially the 49 percent of 1982 visitors who said solitude was "very important" to them (not asked in 1970). Gamma = 0.57 (57 percent of variation in feelings of crowding by visitors who valued solitude accounted for by average number of other parties met per day.)

--"Solitude" number two "high point" 1982 (after "scenery"), cited by 17 percent (not asked in 1970).

--"Crowding" number two "low point" 1982 (after "poor trails"), cited by 9 percent.

--The Wilderness Act requires "outstanding opportunities for solitude."

b. Situation:

--Encounters low, but higher in 1982 than 1970 (table 3).

Table 3.--Encounters with others reported by campers, Bob Marshall Wilderness complex, 1970 and 1982

Campers only	1970	1982
Overall average number of other parties met per day	1.0	1.2
	Percent of total visitors	
Average numbers met per day:		
0	42	26
1-2	48	63
3-5	9	9
6-10	1	2
11-20	0	0
over 20	0	0

--High levels of solitude are a distinguishing characteristic of the BMWC, and standards need to reflect this.

--Only 18 percent said "crowding was a problem."

--But the main change from previous visits was "more use."

--However, most visitors said they met "about right number," and opinions were slightly more favorable in 1982 (table 4).

Table 4.--Campers' opinions of number of visitors they met, Bob Marshall Wilderness complex, 1970 and 1982

Opinion of number met	1970 (Campers)	1982 (Campers)
Too few	2	1
About right	52	60
Too many	32	27
Didn't matter	12	11

--Solitude attitudes are mixed and not always consistent, but there is little basis for setting encounter standards <u>lower</u> than visitors currently are experiencing.

4. Range Utilization

a. Importance:

--Horse use common. (39 percent of visitors on horseback or hiking with stock in 1982. Horse users account for majority of visitor days.)

--Possible competition with wildlife forage.

--Wildlife observation down from 1970 to 1982 and reported elk and deer hunter success down.

--Wilderness Act language--"left unimpaired," "preserve natural conditions," etc.

b. Situation:

--In 1982, average number of horses per party was nine, only 7 percent with over 20 head. Down from 1970 (average 12).

--More supplemental feeding of horses, 75 percent in 1982; 65 percent in 1970. (Others depend entirely on grazing in wilderness.)

--Twenty percent of horse users rejected a campsite because of scarce grazing (1982--not asked in 1970).

--Most common way of holding horses reported in 1982 was "tieu to trees," with high potential for impacts.

REFERENCES

Lucas, Robert C. Use patterns and visitor characteristics, attitudes, and preferences in nine wilderness and other roadless areas. Research Paper INT-253. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 89 p.

Lucas, Robert C. Use patterns, visitor characteristics, and attitudes in the Bob Marshall Wilderness complex, 1970-1982. Research Paper INT-345. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985. 32 p.

APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM IN THE BOB MARSHALL WILDERNESS COMPLEX

John Mercer

The Limits of Acceptable Change (LAC) process apportioned the Bob Marshall Wilderness Complex (BMWC) into four opportunity classes with different standards for each class. Nine indicators were developed that must be inventoried and monitored regularly to determine the state of the resource in each opportunity class. For the LAC process to work, the data have to be analyzed and the information displayed at least on a yearly basis.

Several problems surfaced in meeting these information needs:

--New inventory data, because of the numbers involved, were cumbersome. For example, there were nearly 1,800 campsite inventory forms completed for the BMWC, each with 32 pieces of information.

--The analysis by LAC opportunity classes required considerable manipulation of the data. The opportunity classes have different limits for some indicators. This often requires that the data be sorted by opportunity class as well as by the different standards.

--Many of the data are tied to specific locations in the wilderness. In addition, many indicators are related to unit area and must be displayed on maps. The large size of the BMWC makes this a difficult and time-consuming task.

--The data have to be readily available, easily updated, and stored in a consistent format. Much of the existing information was in dissimilar formats scattered among five different Ranger Districts in the four National Forests that manage the BMWC. These problems have been addressed through the use of the Geographic Information System (GIS).

WHAT IS A GEOGRAPHIC INFORMATION SYSTEM?

There are many different Geographic Information Systems. They evolved in the 1960's and have been in use since that time. In general, a GIS is a computerized data base designed to handle large amounts of spatial as well as nonspatial information. Data can be incorporated from many different sources, including maps, field reports, inventories, and remote sensors such as LANDSAT satellites.

A GIS is very efficient in storing, retrieving, manipulating, analyzing, and displaying data. The user of a GIS can access information based on relationships between different kinds of data. It is helpful to visualize data in the GIS as organized in layers. Topographical data would form one layer, campsite location and inventory data another, and so on. In manipulating data, information layers are overlayed one over the other to determine relationships. For example, in the BMWC one task of the GIS will be to find all campsites that are severely or moderately impacted within Opportunity Class One (most pristine) areas. The resulting data set will be displayed on a map and indicate sites in Class One areas that are violating impact standards. When one considers the nearly 1,800 campsites in the BMWC, this represents a considerable reduction of time required for a tedious and repetitive chore, time that can be better spent on wilderness management problems.

A brief literature review reveals that there is extensive material describing the different kinds of GIS (Marble and Peuquet 1983). They have been used in wildland inventories, in forest management, and in classification of forest communities (Calkins and Tomlinson 1977). Mooneyhan (1982) describes the use of a GIS in Olympic National Park to develop a wildfire prediction model. One interesting feature of a GIS is that the different layers of information tend to reinforce accuracy of the biological and physical data. This has important implications in large wilderness areas like the BMWC, where field inventory data on vegetation and landforms are limited and difficult to obtain.

COMPONENTS OF THE GIS

The GIS used in the BMWC was originally developed by Bain (1984) for the nonwilderness portions of the Flathead National Forest. It was modified during 1984-85 and designed for use in the LAC process and general wilderness management of the BMWC. The software is the raster-based Video Image Communication and Retrieval System (VICARS) used in combination with the Image Based Information System (IBIS). Both were developed by the Jet Propulsion Laboratory in California. The GIS

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system software and mainframe AMDAL computer time are leased from Washington State University at Pullman, and accessed by the Data General 8000 series computer at the Flathead Forest Supervisor's Office in Kalispell, MT. (For more information on GIS and VICAR/IBIS see Colwell 1983).

The GIS has full mapping capabilities integrated with Landsat 3 multispectral imagery. The Landsat imagery provides large scale vegetative mapping of the wilderness at a relatively low cost. In addition to the Landsat vegetative data, the GIS has 57 other data layers including: watershed boundaries, lakes and streams, landtypes II and III, administrative and legislative boundaries, soil types, campsite locations and attributes, LAC opportunity classes, trail locations and attributes, range inventory, range allotments, digital terrain model (topography), slope, aspect, and elevation, administrative sites and structures, grizzly bear habitat, and special use inventories (Tomlinson Associates 1985).

The data layers can be overlayed in almost any fashion to produce new data layers, which can be modified to produce new data layers, and so on. The system has the capacity to conduct searches, make arithmetic and algebraic calculations, do weighted modeling, and measure area, distance, and numbers. The end products can be displayed in tabular form, or on maps at almost any scale.

The bulk of the spatial data was available from conventional sources, such as maps and reports. These data were manually entered in a vector format using the Universal Transverse Mercator grid system and an Numonics digitizing table and later converted to raster form for use with VICARS.

Information specific to the LAC process was collected through campsite, trail, range, and vegetation inventories. The campsite data were manually entered into a Base--II data base management system designed to screen the data for internal errors. After the data were checked and graded for reliability they were stored in standard ASCII files and later converted to the VICAR format. A historical trail map was developed from early records showing all trail segments that were ever maintained in the BMWC since 1917. This information along with trail inventory data was manually digitized.

Ground truth for the Landsat vegetative data was obtained from grizzly bear habitat maps, other wildlife habitat maps, and intensive vegetative inventory of seven inventory blocks totaling approximately 6,000 acres in the BMWC. Landsat data were classified and incorporated in the data base using IBIS and a process developed by Bain. Range survey information was manually entered.

APPLICATION OF THE GIS

The GIS will be used to store and display information on all nine indicators used in the LAC program in the BMWC. It will calculate the four indicators associated with campsites directly from campsite inventory data. In addition, as the GIS is relatively easily updated, it will be used to monitor and display changes in the indicators over time. It will flag areas in opportunity classes that have indicators that exceed the standards. It will also list indicators that are scheduled for reinventory.

The GIS will be used in trail management. Trail inventory data provide information on trail conditions, use levels, maintenance history, and needs. Projected or required maintenance levels can be totaled for miles of trail in each category and displayed graphically. This information can be correlated with per mile costs for each maintenance level and used to develop "what if" scenarios for planning and budgeting of trail dollars. Trail attributes--slope, soils, vegetation, aspect, etc.--can be analyzed to determine which attributes are common to problem areas. A hazard rating system could be developed for new trail location or rerouting. This will help focus reconnaissance efforts in the field and reduce planning time and costs.

The potential exists for campsite analysis using the GIS. It may be possible to identify attributes such as vegetation and soils common to severely impacted campsites and develop predictive capability based on site characteristics. Impacts can be analyzed to determine patterns of use, pinpoint chronic problems, and help the manager focus efforts in the field.

The GIS has important implications for wildlife habitat management in the BMWC. The ability of the GIS to generate overlays of soils, vegetation, aspect, slope, etc. will facilitate habitat identification and maintenance of ecosystem stability and diversity through wildfire management.

LIMITATIONS OF THE GIS

The GIS has the capacity to precisely locate objects such as campsites within a meter square on the ground and display the vegetation and soils for that site. However the accuracy of any overlay is entirely dependent on the quality of the input data. The old cliche, "garbage in--garbage out" is particularly true for GIS systems. An error of four mm on a 1:24,000 scale USGS quad represents an error of 96 meters on the ground. Small errors will have little effect on LAC applications. But they may significantly influence the utility of the GIS analysis of trail and campsite attributes.

It is important that field personnel are properly trained and take the time to collect inventory data and locate campsites and trails as accurately as possible. Field inventory maps greater than 1:24,000 scale increase the possibility of error during the inventory and digitization stages. USGS quads were used exclusively in the BMWC. Ortho-photo quads may enable more precise location of field data in areas with complex topography, or dense forest.

Some individuals resist the use of computers in wilderness management. This may be particularly true of traditional long-time wilderness users, outfitters, and field managers. Some of that reluctance stems from the fear that the computer will usurp the decision making process. It is important to remember that the GIS is merely a tool. In the right circumstances, it has the potential to help the manager identify problems by analyzing large amounts of data rapidly and accurately. It can provide the manager with more time to examine problems and lead to more efficient use of personnel in the field.

AN ONGOING PROCESS

The GIS in the BMWC is scheduled to come on line this fall. After the system is in full operation, much work needs to be done to test the resolution and accuracy of the data. Along with the LAC program, the application of the GIS in the BMWC is an ongoing process that will be continually revised and improved over time.

REFERENCES

Bain, Stan. Landsat geographic information system of Hungry Horse Ranger District. Kalispell, MT: U.S. Department of Agriculture, Forest Service, Flathead National Forest; 1984. Unpublished report.

Calkins, Hugh W.; Tomlinson, Rodger F. Geographic information systems: methods and equipment for land use planning. International Geographical Union, Commission on Geographical Data Sensing and Processing and the U.S. Geological Survey; 1977.

Colwell, Robert N., ed. Manual of remote sensing. Falls Church, VA: American Society of Photogrammetry; 1983.

Marble, Duane F.; Peuquet, Donna J. Geographic information systems and remote sensing. In: Colwell, Robert N., ed. Manual of remote sensing. Falls Church, VA: American Society of Photogrammetry; 1983.

Mooneyhan, Wayne D. Organizing information for effective resource management. In: Johannsen, Chris J.; Sanders, James L., eds. Remote sensing for resource management. Ankeny, IA: Soil Conservation Society of America; 1982.

Tomlinson Associates. 1985. Advanced geographic information systems workloads analysis--Flathead National Forest. Ottawa, ON: Tomlinson Associates; 1985. Individual forest draft report.

WILDERNESS EDUCATION

Ken Wall

In October 1984 the Wilderness Institute at the University of Montana competed against 30 other universities and private consulting firms across the country for a contract from the Washington Office of the Forest Service, U.S. Department of Agriculture, to develop a demonstration project to teach a natural resource issue to agency employees and the public. The Natural Resource and Environmental Education Program (NREE) is a new approach to public education by the Forest Service, with a special emphasis on natural resource issues on individual National Forests.

The project consists of the following components:

1. Background literature, educational materials, and supporting information on wilderness management of the Bob Marshall Wilderness Complex (BMWC).
2. Classroom and field trip education exercises and learning activities on main concepts of managing wilderness ecosystems, written for fifth grade students.
3. Visually oriented material, including a slide-tape program, notebook, brochure, and fact sheets, directed at adult audiences. Reference and source list for background literature, educational materials, and supporting information gathered and indexed throughout the project, supplemented by an annotated bibliography.

The goal of the project is to collect and organize information, and develop educational activities and audio-visual aids to demonstrate a method of teaching the public about a natural resource issue. A second goal is to provide the Flathead, Lewis and Clark, Lolo, and Helena National Forests with educational materials to increase the general public knowledge and awareness of wilderness management problems in the BMWC, and to provide information for wilderness managers to change harmful wilderness behavior and reduce site-specific impacts and user conflicts.

The major management topics for the project are:

1. Background history, and development of philosophies and values that led to the creation of the Wilderness Act.
2. Legislative history, policy, and regulations governing wilderness and the methods used by agencies to manage wilderness.
3. The natural characteristics of wilderness ecosystems.
4. Wilderness skills, etiquette, minimum impact techniques, proper equipment, health hazards, and safety needs.

The project will be completed in December 1985. For more information, contact Ken Wall at the Wilderness Institute, School of Forestry, University of Montana.

SUMMARY OF PROGRESS

Background Material

Now in progress (table 1) are several products to be used as graphic aids for wilderness education efforts. Prototypes for these products will be prepared for Forest Service-sponsored environmental education workshops in August.

The graphic aids include:

1. A 3- by 4-ft map of the National Wilderness Preservation System, showing the location of all areas in the system as of December 31, 1984. The back of the map includes a tabular listing of information on all areas in the system.
2. A portable table and wall display including graphics, photographs, and illustrations with accompanying text, describing the major issues of wilderness management.
3. A collection of 400 slides illustrating the BMWC and major human impacts and management concerns in area. We also have slides representative of recreational use in the area.
4. A 20-minute slide-tape program summarizing the major issues of wilderness management.

Other written support materials will be prepared for these workshops, including a series of 25 fact sheets on management issues, accompanied by supplemental reading lists. Also, a BMWC guide designed to introduce the wilderness complex to inexperienced users and communicate basic no-trace camping techniques will be prepared.

Summary Document

We are preparing a background document, summarizing the major aspects of the issue for the general public. This document will include a condensed two-page summary of the issue, and

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Table 1.--Summary of education products being developed to increase knowledge and awareness of management problems in the Bob Marshall Wilderness Complex

Project components	Products	Target audience
Background materials	Annotated bibliography	All groups
	Resource information	Agency, multiplier, organized group
	Education exercises and activities	5th grade
	Graphic support material --Photo display --Map of the NWPS --Poster	All groups (Agency and general public)
	Reading lists	All groups
Education exercises and activities	Teacher workbook/source book	Teachers
	4-hr classroom unit	5th grade
	2-hr lab unit	5th grade
	1/2- to 1-day field trip	5th grade
	Reference and source materials	5th grade
Visually oriented briefing materials	Slide-tape program	All groups
	Wilderness primer	First-time Wilderness users
	Fact sheets	All groups
	Notebook	Agency and multipliers
Reference and source lists		All groups

relevant material such as reference to laws, management guidelines and policy, and supporting graphics illustrations.

Educational Guide to the Bob Marshall

We are also preparing an extended brochure, approaching small booklet size. It is designed for the inexperienced wilderness visitor, the first time user of the BMWC. It will complement the slide show, or could be used as an independent mailer for general inquiries about the wilderness complex.

The main focus of the primer is to educate the public about wilderness travel and camping techniques and etiquette, and to give them some background on the human and natural history of the wilderness complex. It is directly targeted at reducing impacts from recreational use, the most important management issue according to most agency personnel I have talked to.

Many recreational impacts result from improper use by independent horsemen and pack stock. This audience is also one of the most difficult to reach and educate, and they are the least receptive to education. As a result, I approached Arnold (Smoke) Elser, a well-known and respected outfitter, to write this section of the primer, and he has agreed to do so. Smoke has authored two books on horse use and outfitting in the wilderness, and has been president of the Montana Outfitters and Guides Association. I believe he will have great credibility with horse users, and they might be more receptive to what he writes.

Although the focus of the guide is on no-trace camping techniques and visitor safety, we also want it to be interesting to readers, so it includes some history of the Bob Marshall and early wilderness pioneers, and a section on the flora, fauna, and geology of the wilderness complex.

Table and Wall Display

A portable table and wall display will be prepared to complement the slide show, or to be used alone at conferences, county fairs, and other public events. I have been gathering materials and photos, but have not yet put this together. It will include historic photos of the Bob Marshall, and contemporary photos and drawings of wilderness management issues and concerns. Photos will be captioned. The display will also include maps of the area, and a limited amount of typeset text.

National Wilderness Preservation System Map

I had hoped to have the map of the National Wilderness Preservation System ready for review in early June, but we have been delayed in locating some of the new areas in Washington and California included in the system during the 98th session of Congress.

5th Grade Module

We intend to stay with the original intent of our proposal to develop a three-part module of educational materials and activities for fifth grade use.

1. Background materials and activities, using a similar format to Project Wild and Project Learning Tree, but directing the content to the issue of wilderness management in the BMWC.
2. A lab exercise in the form of a wilderness management simulation game, incorporating all of the issues and concerns addressed in the background material, and allowing the students to apply what they have learned.
3. Activities and materials for an optional one-half day field trip to a "wild" setting, preferably with a wilderness manager, seasonal wilderness ranger, or trained volunteer to serve as a resource person.

Printed materials will be bound with an index of references and subjects, and a glossary.

Fact Sheet

Fact sheets are written for a lay audience and are designed to be used with the slide show, brochure, and table display. Each fact sheet will stand on its own, or they could be used as a set. They also might be useful at Ranger District offices and other areas where public contact occurs.

Slide Show

The slide show will be 20 minutes long, covering the major aspects of the issue of wilderness management in the BMWC. It will include several graphic slides to show the relationship of the BMWC to other wilderness areas in Montana and the Country, and the types and characteristics of wilderness use. It will also cover other aspects of wilderness management besides recreational use, such as management of natural wildfires and threatened and endangered species.

BIBLIOGRAPHY AND SOURCE LIST

We have collected and indexed much information on the issues of wilderness management and specifically on the BMWC. This collection includes the following:

1. A computer data base bibliographic file on wilderness management and the BMWC with 1,500 citations. Half of these citations are annotated. These citations include research and popular articles, books, dissertations, films, and brochures.
2. A collection of written material, including roughly 500 articles, research reports, management plans, federal laws, policy statements, brochures, maps, and other supporting documents that relate to management of the BMWC.
3. A collection of information on environmental and wilderness education centers across the United States, and samples of curriculum and interpretive materials distributed through these centers.

Based on comments on the last progress report that the 1,500-citation bibliography and source list includes too many technical references, and will overwhelm the lay audience, I have split the bibliography into two separate reference and source lists. The technical list is directed at land managers and researchers, and the non-technical list is directed at the lay audience. The list primarily contains articles and books; we have recently been adding slide shows, films, brochures, and other audio-visual aids available to the public. The best references and general overview articles will also be in the fact sheets for each topic.

AN ALTERNATIVE TO RATIONAL-COMPREHENSIVE PLANNING: TRANSACTIVE PLANNING

Stephen F. McCool, Joseph L. Ashor, and Gerald L. Stokes

Rational-comprehensive or synoptic planning is the most prevalent form of planning used today. Braybrooke and Lindblom (1963) define this form of planning as "the ideal way to make policy by choosing among alternatives after careful and complete study of all possible courses of action and their possible consequences in light of one's values." Synoptic planning involves a systematic process in which objectives are formulated, alternatives are identified, choice criteria are applied to the alternatives, and a recommended course of action is identified. The planner's tools are analysis, quantitative models, and explicitly established and formalized procedures for the conduct of the planning process. Information requirements are normally considerable, with an emphasis on information that can be quantified.

A problem with the rational-comprehensive approach is that the encompassing information requirements for a truly comprehensive model are unrealistic. As McLaughlin (1977) suggests, "the complete information requirement has been replaced by the best available or most affordable information, both of which seem to have become an acceptable end."

Others have criticized the synoptic planning approach from the perspective of the limitation of available knowledge and man's intellectual and problem solving abilities (Braybrooke and Lindblom 1963). The data gathering necessary for comprehensive analysis is often extremely costly. Freeman (1974) finds synoptic planning inadequate because goals are frequently multiple and inconsistent. Bolan (1967) also criticizes synoptic planning in terms of the planner's inability to determine goals or values, which are often in a state of flux. Grabow and Heskin (1973) argue that the centralizing and change-resistant technology of synoptic planning is largely the reason its goal of a systematic, rational approach to problem solving is unattainable. Sterile, technocratic, and centralized planning, with its relatively large information and budget requirements, seems out of place in a dynamic, politicized planning situation where funds are limited.

Transactive planning has been developed by Friedmann (1973) as a response to the deficiencies and problems posed by traditional synoptic planning. Friedmann feels that alternatives to solving social problems by centralized decision making must be developed, and that such an alternative process should include those impacted. Friedmann then suggests that small working groups of citizens form the basis of his transactive planning process. Such working groups, because of their relatively small size, encourage face-to-face communication and dialogue, and provide a setting where participants can acquire and use technical knowledge.

In these working groups, participants share their intimate knowledge and experiences with the planner, who shares the technical planning models and systematic ways of data manipulation with the citizens. The dialogue that develops leads to mutual learning, a learning which accumulates to both the citizen and the planner. Through the dialogue and learning processes, decision situations are eventually confronted. The working group, using its accumulated knowledge, makes an informed decision about a course of action. Because the working group is a microcosm of the political marketplace, decisions made by it are enforceable by various political actors.

There are fundamental structural differences between citizen involvement in transactive planning and how it is used in synoptic planning. In transactive planning, the citizen participant is viewed not only as having expertise about the subject matter, but also as an individual who has the capacity to act rationally, within the context of a working group. In a sense, the planner and citizen work as partners in developing actions to solve problems. In many ways, citizen involvement in synoptic planning situations has been superficial and adversarial. Citizens are asked only to respond to plans created by planners working in relatively insulated environments. Complete understanding of the problem is less likely because of the minimal role citizens play in plan development. Because agencies ask citizens to review plans, an adversarial role is intrinsic in the planning process. This leads to agency-citizen tension and dissatisfaction with the plan.

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REFERENCES

Bolan, R. S. Emerging views of planning. Journal of the American Institute of Planning. 33(4): 233-245; 1967.

Braybrooke, D.; Lindblom, C. E. A strategy of decision. New York: The Free Press; 1963.

Freeman, D. M. Technology and society: issues in assessment, conflict and choice. Chicago: Rand McNally College Publishing; 1974.

Friedmann, J. Retracking America. Garden City, NY: Anchor Press/Doubleday; 1973.

Grabow, S.; Heskin, A. Foundations for a radical concept of planning. Journal of the American Institute of Planners. 39(2): 106-114; 1973.

McLaughlin, W. J. The Indian Hills experiment-- A case study in transactive planning theory. Fort Collins, CO: Colorado State University; 1977. Dissertation.

LAC TASK FORCE ROLE

Gerald L. Stokes

The LAC Task Force was assembled in February of 1982 and has been gradually expanded since that time. The task force has functioned as an ad hoc umbrella group that is composed of managerial, research, and citizens components. All full task force meetings have included all three components. Thus the LAC Task Force can be seen as a three-legged stool with a managerial leg, a research leg, and a citizens leg. This composition of representatives allows the opportunity for sharing technical/scientific knowledge and personal knowledge (that gained through on-the-ground experience) among participants. Most citizens' representatives have personal knowledge of the Bob Marshall Wilderness Complex (BMWC) based on their experience as users. Many of them also have technical knowledge to share with others.

The managers have both personal knowledge of the area and scientific/technical background and knowledge and the researchers provide concepts such as Limits of Acceptable Change (LAC) and the best scientific data and analysis that is available. Through discussions and dialogue at general task force meetings and smaller subgroup meetings, the personal knowledge of all representatives becomes integrated with the collective scientific/technical knowledge of the group. This should provide:

1. Validation or tempering of scientific/theoretical/technical information with the personal knowledge of users and managers.
2. Validation or tempering of the collective personal knowledge of the group with scientific/technical data, analysis, and methodology.

The result should be the most accurate description of the real world management situation in the BMWC. This should also result in the most accurate assessment possible of what should and can be achieved to maintain or enhance that management situation, what the future real world state of affairs of the BMWC should be, and how to achieve that future state; that is, what management actions should be taken.

This process may be summarized (fig.1) as follows:

Dialogue and discussion within and among the three components of the task force results in mutual learning about the BMWC through sharing of personal and scientific/technical knowledge of the area. This mutual learning provides an opportunity to develop a consensus on what the state of affairs in the BMWC is and what, if anything, should be done to improve it. The final result would then be a course of action (direction for managing recreation use) that is scientifically, politically, and administratively justified, supportable, and defensible.

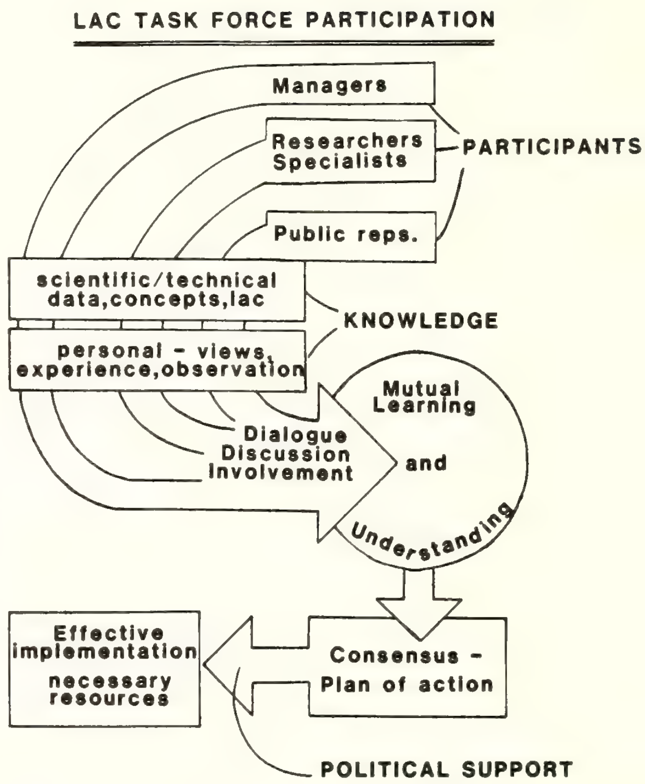

Figure 1.--Diagram showing participants in the LAC Task Force and how they interact to produce a consensus plan of action.

This process is based on several assumptions:

1. The scientific/technical data we have, although not all-inclusive, are adequate for this first-generation LAC planning effort and can be refined over time to fine tune conclusions and management direction based on the data.
2. The collective personal knowledge of users, managers, and researchers is sufficient to complement, validate, or refine conclusions based on the data.

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3. Managers, citizens' representatives, and researchers are willing to participate openly within the task force framework to develop a sense of shared ownership in the BMWC management challenges and development of solutions to those challenges.

4. The citizens component includes a sufficiently broad spectrum of BMWC interest groups to constitute a microcosm of local, regional, and national interest in the BMWC. The task force is not, however, necessarily representative of all wilderness interest groups. The formal public review process provides the opportunity for any groups or individuals not included in the task force to make their views known.

5. The citizens component provides an adequate "political market place" wherein the bargaining and tradeoffs necessary to develop a consensus can be conducted.

6. Managers responsible for legislative mandates and administrative policies emanating from the Wilderness Act will ensure that all solutions/directions are consistent with existing mandates and policies. All direction for managing recreation use in the BMWC must provide "for the American people of present and future generations the benefits of an enduring resource of wilderness."

7. The composition of the citizens component constitutes a potential viable political coalition that can ensure the LAC management direction and the managerial actions necessary to implement that direction are carried out. This coalition should continue to function after LAC direction is developed. This coalition could ensure adequate extra-agency political support and internal agency managerial support would be provided for implementation and ongoing monitoring. Some formal supporting organization might be formed by the citizens' representatives at their own initiative.

8. Solutions developed under the umbrella of the LAC Task Force will fall within the sideboards established by the Wilderness Act and subsequent policies and regulations. The composition of the citizens component should ensure wilderness resource values are adequately addressed within the context of Wilderness Act intent. If this does not occur, managerial prerogatives based on agency policies and regulations will be exercised.

9. What is acceptable and supportable by the citizens component will be acceptable and supportable by the population at large.

10. The formal public review of LAC draft direction developed by the task force will either validate or invalidate items 8 and 9.

An interForest core team was formalized under the auspices of the LAC Action Plan, which was signed by all four Forest Supervisors in August 1983, to develop a draft plan. Both managerial and research components have been intensively involved in this effort. The core team along with its research support operates as the technical arm of the LAC Task Force as a whole.

The task force has operated as a whole and in subgroups that have been formed to develop recommendations for particularly difficult problems or provide for a local forum to discuss the plan. The LAC Coordinator has been meeting with these subgroups to discuss the core team's efforts and progress and to get their further input regarding those efforts. As sufficient progress is made to warrant a general meeting, the full LAC Task Force is convened.

As managers deemed appropriate, they have involved other area-specific constituents not already included.

Following is a list of the representation that has been or is now included in the LAC Task Force.

The Wilderness Society
Sierra Club (State Chapter)
Back Country Horsemen of America and three area-specific chapters
Professional Wilderness Outfitters
Montana Outfitters and Guides Association
Montana Wilderness Association with two area-specific chapters
National Forest Recreation Association
Unaffiliated Users
Lincoln, MT, citizens subgroup
Swan Valley citizens subgroup
Flathead National Forest
Helena National Forest
Lewis and Clark National Forest
Lolo National Forest
University of Idaho
Montana State University
University of Montana
Montana Department of Fish, Wildlife, and Parks
Wilderness Management Research Unit, Intermountain Research Station
Wilderness Institute, University of Montana

ONGOING MANAGEMENT CONSULTATION PROCESS

Gerald L. Stokes

The underlying fact related to implementation of Limits of Acceptable Change (LAC) direction in general and associated management actions specifically is that management decisions will be made by the wilderness manager (District Ranger). This paper describes the wilderness manager's consultation options regarding the citizens' component of the LAC Task Force. This assumes ongoing involvement of the Task Force in LAC implementation through periodic meetings to discuss progress and problems.

Through the LAC Task Force development of the draft plan, wilderness managers are consulting with a diverse group of wilderness interest group representatives that comprise a political marketplace and a potential political coalition from whom the managers need support in order to implement LAC. This consultation will result in a set of management actions identified in the plan that will be available for the manager to use in achieving or maintaining conditions within standards. This set of managerial actions may be viewed as a bundle of sticks of varying sizes. Little sticks are nonregulatory and adversely affect few, if any, of the public in terms of convenience or freedom. As the sticks increase in size, they result in greater inconvenience or loss of freedom. Therefore, the sticks (management actions) can be arranged from nonregulatory to regulatory in their effects on users. This array of management actions can be displayed as the bundle of sticks available to the manager across the entire wilderness complex, by opportunity class bundle, or in area- or site-specific bundles. The configuration and the composition of bundles has been determined through the Task Force deliberations and the subsequent formal public review process. The final outcome is a legitimized bundle or bundles of management actions available to the manager falling in a nonregulatory to regulatory continuum.

Once the management actions are legitimized (supported or consented to through the Task Force and the formal public review and subsequent decision by the responsible line officer), the wilderness manager is technically free to choose and apply the management actions as necessary. In most situations, this exercise of managerial prerogative with no further consultation would be appropriate and acceptable to the public. This assumes that most actions will not entail use of big sticks. Where the use of big sticks becomes necessary, the manager has three choices:

1. Assume the adoption of the plan provides sufficient legitimation of all management actions and that use of a big stick requires no further consultation.
2. Acknowledge the big stick action is legitimate but elect to consult further with the Task Force on planned actions regarding a specific situation, area, or problem that requires a regulatory response.
3. Present the problem and ask the Task Force for a recommended solution.

Option 1 would not provide the manager with a current sense of the political support existing in the public or segments of the public, as indicated by the Task Force representation.

Option 2 would give the manager a sense of the political ramifications of intended actions in that the Task Force response to the proposed action would serve as a bellweather of general public response or responses of segments of the public. In essence, the manager could sound out the level of general Task Force support or support of some groups as interveners on the behalf of management if there is an appeal, or in communicating the need for the action to the general public and achieving public acceptance without major public opposition. The breadth and depth of opposition as well as support could be sensed through this approach.

Option 3 is essentially the same as 2 except it places the citizen Task Force members more in a position of responsibility for the problem and the solution and therefore potentially creating more ownership in and support of the manager's subsequent action.

The politically prudent manager would consult on an annual basis with the Task Force on problems that warrant consideration of big stick solutions. Option 2 or 3 would be used and the resulting sense heeded by the prudent manager. In both options, the manager would be free to use managerial prerogative in taking action that is contrary to the sense of the Task Force. A manager would probably do so with an understanding of the risks, cost, and probability of success of the proposed action.

If a problem comes up that warrants immediate action to deal with protecting the resource, the manager has the mandate to act without further consultation with anyone. If the situation

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warrants, the manager should act immediately. If immediate action is not warranted, then further legitimization of management actions with the Task Force should be considered. Subsequent consultation with the Task Force regarding emergency actions would be appropriate.

If a situation arises for which no appropriate legitimized management action exists and no emergency exists, the politically prudent manager would consult with the Task Force at the next periodic meeting. Option 2 or 3 would be used to legitimize a new management action needed to deal with an unforeseen situation/problem.

CRITERIA AND GUIDELINES FOR USING THE TRANSACTIVE PLANNING APPROACH IN WILDERNESS MANAGEMENT PLANNING

Joseph L. Ashor

Current research (Ashor 1985), and past research into transactive planning (Stokes 1982), has uncovered a set of criteria crucial to successful wilderness planning using the Limits of Acceptable Change (LAC) system and a transactive style of planning. A potential planning atmosphere should be evaluated by planners according to the reality of conforming in a rough way to these physical and social criteria before planning begins.

PLANNING CRITERIA

1. The plan will address important and serious problems that exist within the wilderness. People are unlikely to get involved unless they perceive there are problems worth addressing.

2. The planning environment should be manageable from both a physical and social standpoint. The actual size of the wilderness should be not so large as to overwhelm the technical capability of planners and their ability to organize meetings in convenient, central locations. If more than one National Forest or Ranger District is involved, as is often the case, all must be willing to commit the necessary resources to accomplish the task. The number of issues to be addressed should also be manageable and not overly comprehensive and complex. Also important is that the number of interest groups is not so large so as to make general task force meetings unresponsive and ineffective.

3. There must exist a potential for planners to organize citizen participants into a viable political coalition. Enough groups or individuals must be interested in participating to comprise a political marketplace. Those citizens with veto power must be willing to participate, or at least acquiesce to using an LAC planning framework (Stokes 1982).

4. The planners must have a wide range of personal characteristics and have at their disposal the appropriate tools to adequately and effectively progress through the nine-step LAC process. This means the planner using a transactive style of planning. . .

a. must have thorough knowledge of the LAC system, the rationale behind it, and how it is to be applied in their area,

b. must have the personnel and experienced field people to conduct an inventory of the indicators selected,

c. must have a willingness to serve people beyond what would be minimally acceptable and have the ability to bring the necessary people and tools together to foster dialogue and mutual learning (Stokes 1982),

d. must be skilled in managing interpersonal relations, have a heightened capacity for empathy, be willing to live with conflict, and have an understanding of the dynamics of power and the art of using that power to accomplish planning goals (Friedmann 1973),

e. must be a good leader, someone who is credible in the eyes of citizen participants both in terms of technical proficiency and trustworthiness; must have the confidence and trust of the people, and

f. should be committed to a transactive style of planning in which the scientific/technical knowledge is joined with the personal knowledge of the citizen through the life of dialogue which leads to mutual learning (Stokes 1982).

PLANNING GUIDELINES

The following guidelines are provided for managers and planners who might wish to use the LAC system and the transactive planning approach (based on Aleshire 1970; Ashor 1985; Glass 1979).

1. The design of the planning process should receive close attention and scrutiny. The most important factor here is the provision of many avenues for participation and involvement. Techniques are merely potential tools or means for achieving planning objectives. Certain techniques are more appropriate than others in achieving a particular objective. Therefore, along with using many techniques, attention should be paid to matching those techniques with certain citizen participation objectives (table 1). By utilizing a wide variety of participatory techniques, the weaknesses of one can be overcome by the strengths of another.

2. Ensure that interest group representation is comprehensive, or at least diverse enough to include all major groups who might be affected by the proposed management plan. Orchestrating the formation of the task force and making sure it has all the key players is one of the most important tasks of the planner.

Planners need not include all possible interest groups at the first meeting. Attempts to be overly comprehensive in the beginning increase the chances of not being able to get the process launched. However, the flexibility and openness of the process should eventually allow for diverse

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Table 1.-- Citizen participation techniques used in the Bob Marshall Wilderness Complex planning effort with associated objectives

Planning technique	Citizen Participation Objectives Exchange information	Education of citizens	Building support	Supplemental decision making	Representational input
Task Force meetings[1]	x	x	x		x
Agency information meetings	x	x	x		x
Small subgroups[1]	x	x	x		x
Citizen/ agency workshop	x	x	x		x
Nominal group process				x	x
Surveys					x
Public mass meetings	x				
Problem analysis committees[1]	x			x	
Citizen interviews	x				x
Field trips[1]	x	x	x		

[1]Planning techniques most likely to promote dialogue and mutual learning.

and equitable representation. But, those with first-level veto power should be included as soon as possible; that is, those groups who have the most political clout to nullify planning efforts. Outfitter and guide organizations and national conservation and environmental clubs are some of the groups that usually hold first-level veto power. A rescanning of the task force make up should also take place periodically to ensure that those with veto power are eventually included. If individuals are brought into the process fairly late, they need to be educated about LAC and the purpose of the task force before they can effectively contribute to it.

3. The size of the planning team should be small enough to facilitate an easy exchange of personal and technical/scientific knowledge. Main task force meetings should contain no more than 25 to 30 participants. Smaller, task-oriented working groups or subgroup meetings operate most effectively with several to nine people. These meetings should be frequent enough to keep the process fresh in peoples' minds. Face-to-face dialogue should occur throughout the entire planning process.

4. Inform all participants of their role in the planning process. Citizen members of the planning team should be encouraged to develop their own solutions and management actions to solve problems, in short, to play the role of planning for themselves. If managers plan to use citizen-generated alternatives as part of the actual plan, citizens should be informed beforehand so as to increase the chances of them generating realistic alternatives. It should also be made clear to citizens that although their input and knowledge will be heavily relied upon, the final decisions rest with the managers. Planners must not make the mistake of using the citizens as decision makers. The role of the agency is still that of final decision maker. Informing citizen participants of their role is especially important in avoiding unrealistic expectations of the outcomes of the process.

5. Respond to problem situations immediately. Problem situations usually arise due to inadequate or faulty communication and misunderstandings. Citizens or other government agency officials who do not understand the LAC process or the nature of the public involvement can often do substantial harm. Keeping the

process on track means responding to these individuals as quickly as possible so as to avoid a situation that could possibly balloon out of proportion and beyond the control of planners and supportive planning team members.

6. Continue citizen participation after the formal planning process has been completed. Continued involvement of citizen task force members is vital to successful implementation of a management plan that utilizes LAC or any other management system. At a minimum, the task force should meet annually to evaluate the past season's management activities. This will help ensure that agreed-upon management actions and monitoring schedules are being adhered to by managers. It will also give managers and citizens a chance to reevaluate the effectiveness of key parts of the plan such as resource or social indicators. The flexibility of the LAC system is such that if an indicator or other aspects of the system are obviously not serving a useful purpose, they can be dropped and new indicators added and tried. This flexibility warrants continued input from users and citizens to ensure they accept any proposed changes or controversial management actions. It will also help maintain the high level of support and cooperative spirit needed for effective implementation.

Although these guidelines will help to provide a basic strategic framework for managers and planners who might wish to use the LAC/transactive planning approach, they will by no means guarantee its success. Fundamental to understanding the total process is realizing that there exist many bits and pieces that cannot be easily conveyed as simple rules or guidelines. Much of this is an art, a subtle process rather than something that can be taught and learned. The lead planner must rely heavily on intuitive path finding. A sense of what to do next to orchestrate a myriad of underlying agendas and when to initiate subtle actions can be just as much responsible for a successful process as other, more easily defined procedures. Again, the traditional planning activities are important, but only if effectively combined with less tangible, more humanistic characteristics of the process.

REFERENCES

Aleshire, Robert A. Planning and citizen participation: costs, benefits and approaches. Urban Affairs Quarterly. 5(4): 369-393; 1970.

Ashor, Joseph L. Recreation management in the Bob Marshall Wilderness Complex: an application of the Limits of Acceptable Change concept and transactive planning theory. Missoula, MT: University of Montana; 1985. 224 p. M.S. thesis.

Friedmann, John. The public interest and community participation: toward a reconstruction of public philosophy. Journal of the American Institute of Planners. 39(1): 2-12; 1973.

Glass, James J. Citizen participation in planning: the relationship between objectives and techniques. Journal of the American Planning Association. 45(2): 180-189; 1979.

Stokes, Gerald L. Conservation of the Blackfoot River Corridor--an application of transactive planning theory. Fort Collins, CO: Colorado State University; 1982. 229 p. Ph.D. dissertation.

BASIS FOR SUCCESS OF BMWC LAC PROCESS SUPPORTED IN

CURRENT BEST-SELLING POPULAR LITERATURE

Gerald L. Stokes

Following are quotes from In Search of Excellence and Megatrends that I feel are relevant to the wilderness planning endeavor in the Bob Marshall Wilderness Complex.

IN SEARCH OF EXCELLENCE

1. Product champions--those individuals who believe so strongly in their ideas that they take it on themselves to damn the bureaucracy and maneuver their projects through the system and out to the customer. P. xvi.

2. Those who implement the plans must make the plans. P. 31.

3. Creative thought (the precursor to invention) requires an act of faith. P. 47.

4. The scientific paper presents an immaculate appearance which reproduces little or nothing of the intuitive leaps, false starts, mistakes, loose ends, and happy accidents that actually cluttered up the inquiry. P. 48.

5. Pathfinding is essentially an esthetic, intuitive process, a design process. P. 53.

6. Both Warren Bennis in The Temporary Society and Alvin Toffler in Future Shock identified the need for the adhocracy as a way of corporate life. In rapidly changing times, they argued, the bureaucracy is not enough. By "the bureaucracy," they mean the formal organization structure that has been established to deal with the routine, day-in, day-out items of business--sales, manufacturing, and so on. By "the adhocracy," they mean organizational mechanisms that deal with all the new issues that either fall between bureaucratic cracks or span so many levels in the bureaucracy that it's not clear who should do what; consequently, nobody does anything. P. 121.

7. The task force is an exciting, fluid, ad hoc device in the excellent companies. It is virtually the way of solving and managing thorny problems, and an unparalleled spur to practical action. P. 132.

8. . . . one term for experimenting is 'bootlegging.' (The parallel term is "scrounging.") There the tradition of squirreling away a little bit of money, a little bit of manpower and working outside the mainstream of the organization is time honored. P. 144.

9. The new idea either finds a champion or dies . . . No ordinary involvement with a new idea provides the energy required to cope with the indifference and resistance that major technological change provokes . . . Champions of new inventions display persistence and courage of heroic quality. P. 200.

10. A special attribute of the success-oriented, positive, and innovating environment is a substantial tolerance for failure. You need the ability to fail. You cannot innovate unless you are willing to accept mistakes.

MEGATRENDS

1. High tech/high touch is a formula I use to describe the way we have responded to technology. What happens is that whenever a new technology is introduced into society, there must be a counterbalancing human response--that is, high touch--or the technology is rejected. The more high tech, the more high touch. P. 35.

(High tech--LAC process, data, and Geographic Information System (GIS); high touch--Task Force and intimate human involvement and interaction in the process).

2. People whose lives are affected by a decision must be part of the process of arriving at that decision. . . . participatory democracy has seeped into the core of our value system. Its greatest impact will be in government and corporations. P. 175

3. . . . we (the citizens) have grown more confident of our own ability to make decisions about how institutions, including government and corporations, should operate. P. 177.

4. Technical decisions are moving out of the hands of the so-called experts and into the political arena. P. 184.

5. It isn't technology, it's politics. It isn't facts, it's perceptions. P. 185.

6. People must feel that they have ownership in a decision if they are to support it with any enthusiasm. P. 209.

7. The new leader is a facilitator, not an order giver. P. 209.

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Includes more than 70 reports of current wilderness research. Papers are organized around nine topics: wilderness resource research, including natural fire, air quality, impacts to soil and vegetation, fish and wildlife, and water; and wilderness user research related to recreational use and user characteristics, attitudes and behavior, benefits, and management concepts and tools.

KEYWORDS: research needs, management planning, use impacts, monitoring, visitor behavior, visitor education, wilderness wildlife

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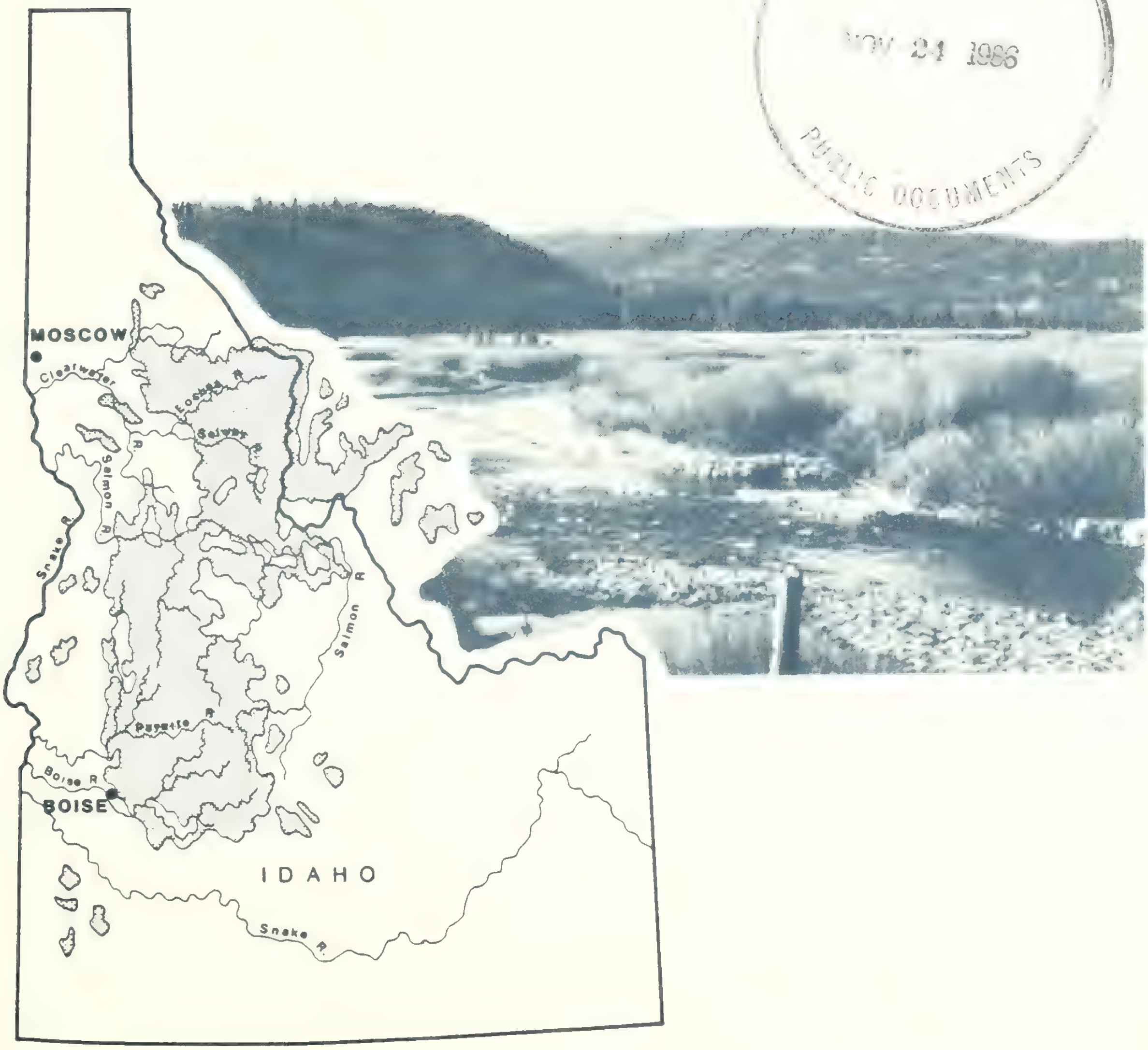
Sediment Rating Equations: An Evaluation for Streams in the Idaho Batholith

Gary L. Ketcheson



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RESEARCH SUMMARY

Sediment data collected on streams from National Forests and a watershed research study area in the Idaho batholith were used to develop suspended, bedload, and total sediment rating equations. This report discusses the statistics associated with 125 suspended, 121 bedload, and 119 total sediment rating equations. For streams where the timing and amount of management activities within the watershed were documented, any shifts in rating equations were compared with the timing of these activities. Some shifts in rating equations coincided with the occurrence of management activities while others did not.

Sediment yields were estimated using rating equations and a time-integration technique for data from the Boise National Forest. The two methods gave significantly different estimates of total annual sediment yield. For the research data the same predictions were made and compared with estimated sediment yield from sediment dams at the mouths of the drainages. The rating equation and time-integration techniques estimated similar sediment yields that were also similar to those from the sediment dams. However, the time-integration estimates more closely matched those from the sediment dams.

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Sediment Rating Equations: An Evaluation for Streams in the Idaho Batholith

Gary L. Ketcheson

INTRODUCTION

Sediment transport rates in streams and rivers have been measured for various reasons for many years. The U.S. Army Corps of Engineers began sediment sampling as early as 1838 in relation to navigation work on the Mississippi River (Livesey 1975). Most of the early sampling was done by groups such as the Corps, the Bureau of Reclamation, and the Soil Conservation Service (SCS) in response to the Flood Control Acts of 1928 and 1936. The purpose of the sampling was to predict sediment yields for planning flood prevention and control, water storage facilities, and large river basin studies. The sediment rating curve method of sediment prediction was developed in the 1930's. It was used extensively by the Corps of Engineers (Livesey 1975), the Bureau of Reclamation (Strand 1975), and the Soil Conservation Service (Holeman 1975) for large river analyses during the 1930's and 1940's.

In the 1940's and 1950's, emphasis in the Corps began to change from large river analyses to smaller watersheds. At the same time, analyses were being completed on an ever-increasing number of sites with shorter times from planning to implementation. This caused a shift from the rating equation method to the use of predictive equations correlating sediment yield from reservoir surveys to physical watershed characteristics and management activities. The SCS has moved away from the rating equation method due to shorter analysis times and to the variability of the sediment-discharge relationship (Holeman 1975).

Land management agencies have become increasingly involved in sediment measurements over the last 30 years. Sediment in streams was identified as a pollutant in the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). This and the passage of the National Forest Management Act of 1976 (NFMA) created a need to quantify sediment production, especially from National Forest lands. The development of Forest land management required quantified estimates of sediment yields. State water quality laws also became more specific in relation to sediment.

Suspended sediment measurement techniques have been well described and tested since the 1940's. Effective bedload measurement methods have only recently been developed. For this reason discussions regarding sediment rating equations in the literature have been restricted to suspended sediment rating equations. Also, much of the sediment data collected in the past are from large river systems where bedload sediment accounts for only 5 to 10 percent of the total sediment load (Anderson 1975; Emmett 1975). Rannie (1977) notes that even though the suspended sediment rating equation has received nearly universal acceptance as a hydrologic and geomorphologic tool, the curves themselves have received little attention. Rating curves are usually reported for individual studies with no general standards for comparing them with curves developed elsewhere. Rannie used watershed characteristics to predict rating equation coefficients. This follows from the assumption that suspended sediment is derived mainly from processes that operate throughout the watershed and that are imposed upon the channel, versus bedload transport, which is more dependent on channel hydraulics.

There has been limited application of sediment rating curves for small streams in the Northern Rocky Mountains. Much of the work is from third-order streams underlain by highly metamorphosed sedimentary rocks and glaciated granitics. Bedload makes up only 5 percent of the total sediment load from these watersheds (Rosgen 1980). Little attention has been given to the reliability of the sediment rating curves or to the statistics associated with the regressions.

This paper discusses sediment rating curves for streams in the Idaho batholith region. The granitic bedrock in this region is highly weathered, and the resulting soils are shallow, coarse textured, and noncohesive, which results in high erosion rates. The annual sediment yield contains 60 to 70 percent bedload. This paper will discuss the statistical reliability of the rating equations, their usefulness in monitoring watershed response to management, and their effectiveness in determining sediment yields, and will compare different techniques for estimating sediment yields.

Suspended sediment rating equations take the form:

$$Q_s = aQ^b \tag{1}$$

where:

Q_s = sediment concentration
Q = stream discharge
a and b = coefficients.

Flaxman (1975) described watersheds in relation to the value of b. However, when b became small, a nearly independent relationship between discharge and sediment concentration resulted. An unlimited supply of fine sediment in the streambed and banks might result in low-flow and high-flow sediment concentrations of equal magnitude. Flaxman developed a significant predictive equation for a using average annual runoff and the b coefficient. He then predicted undisturbed suspended sediment rating equations for three Western United States streams by assuming a value for b for undisturbed conditions. These curves were then compared with rating curves developed from sample data on these watersheds, which have undergone development. The difference between the predicted curves and the actual curves was attributed to development impacts.

Rosgen (1980) presents one method for predicting relative changes in potential sediment discharge from silvicultural activities using sediment rating curves. This procedure assumes that sediment rating curves are constants. But when used in conjunction with predicted streamflow increases following disturbance, the procedure can predict relative changes in sediment following silvicultural activities. The fact that shifts do occur in sediment rating curves due to disturbances and floods is recognized, but this procedure does not predict these changes.

The role of sediment supply in determining the sediment rating curve has gained increasing attention. Shen (1972) noted that for large rivers carrying mostly suspended sediment and little bedload, sediment transport of the river is more dependent upon supply from the watershed than on transport capacity. The amount of fine sediment in streamflow is more dependent on the intensity and location of rainfall, cover conditions, and other watershed factors than on water discharge. Bedload sediment derived from channel erosion should be more closely correlated with streamflow (Holeman 1975). Van Sickle and Beschta (1983) propose a supply-based model for small streams that uses the suspended sediment rating curve and a supply depletion function. The supply function expresses a declining suspended sediment concentration to reflect storm hysteresis and seasonal decline of sediment supply.

Simultaneous measurements of sediment and streamflow are required to develop a sediment rating equation. The intended use of the rating equation dictates how these measurements are taken. If an average annual sediment yield estimate is desired, the sediment and discharge should be taken over several years (if time permits) and include a wide range of flows. The resulting composite sediment rating curve can be used with a long-term flow duration curve to estimate the expected annual sediment for a typical year. Streamflow is not always available for the entire year or period of sediment measurement. If it isn't available, the flow duration curve must be developed by correlating the instantaneous streamflow measured in conjunction with sediment sampling with streamflow records of a nearby gauging station. Extreme hydrologic events (floods and droughts) and management impacts can significantly affect sediment discharge. Sediment rating equations developed from data collected during these events may not reflect average conditions. This should be remembered when analyzing data for sediment rating equation development.

If the intended use of the rating curve is to estimate yearly sediment yields, or to monitor the effects of watershed disturbances on sediment yield, or both, annual rating curves should be developed. Actual or estimated streamflow for each year is used to estimate annual sediment yield. Estimates of streamflow could again be obtained by correlation with nearby gauging station records. In this case, mean daily flows are used in the sediment rating curve to calculate daily sediment. The daily sediment values are added to estimate annual sediment yield.

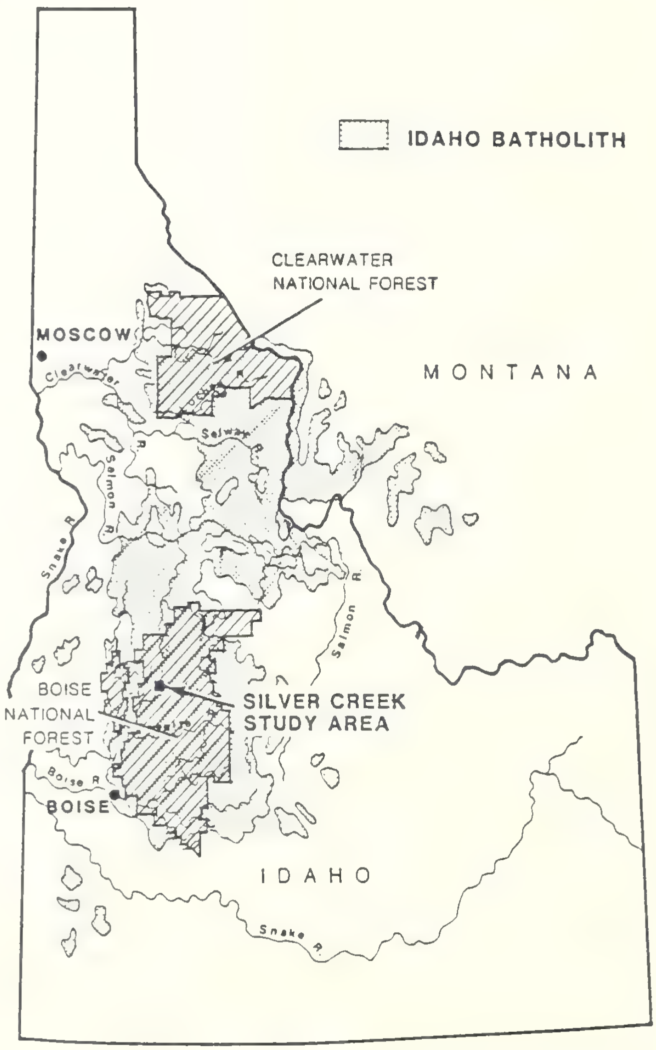

Figure 1—Locations of the Idaho batholith, Clearwater and Boise National Forests, and Silver Creek study area in Idaho.

THE DATA

The sediment rating curves discussed in this paper are derived from data collected on the Boise and Clearwater National Forests and from watershed research in the Silver Creek area (fig. 1). The Idaho batholith is within the Northern Rocky Mountain Geomorphic Province. The streams on the Clearwater National Forest are within the Lochsa Uplands section and are characterized by moderate slopes (30 to 50 percent) with steeper lower canyon areas draining the rejuvenated uplands. The streams on the Boise National Forest, which includes those in the Silver Creek area, are in the southern batholith section where steep, strongly dissected slopes (50 to 70 percent) dominate. Streamflow and sediment transport reach a peak in response to melting winter snowpacks during April and May. Intense summer thunderstorms occasionally cause significant flow increases, but these and the associated sediment discharge are small relative to the spring snowmelt peaks. For information on precipitation and streamflow for these areas, see Idaho Water Resources Board (1968).

The data include instantaneous suspended and bedload sediment and concurrent streamflow. Suspended sediment is sampled with DH-48 depth-integrating samplers. Helley-Smith samplers are used for sampling bedload sediment. Streamflow is measured each time with current meters.

Forest Data

Sampling on the Boise and Clearwater National Forests was concentrated around the spring snowmelt peak with samples taken infrequently during the summer and fall months. The number of samples per year varied from five to 20 with a mean of 10. Sediment rating curves were developed for suspended, bedload, and total sediment for each year of record and for the period of record. Total sediment rating curves were developed by regressing discharge on the sum of the DH-48 and Helley-Smith sediment values. The 10 streams on the Boise National Forest had 3 to 5 years of record. Seven streams included in this report from the Clearwater National Forest had 3 to 8 years of record. All streams had various levels and ages of land management. The watersheds varied in size from 244 to 2,298 ha.

Two methods were used to calculate sediment yield. The rating equation approach required continuous streamflow records for the monitored stream, or a correlation between instantaneous flows measured on the monitored stream with mean daily flows from a nearby stream gauge. If the correlation was good ($R^2 \geq 0.60$), the gauged stream was used to generate streamflow values for the sediment rating equation. The rating equation method integrates based on streamflow fluctuations. Stream gauge records did not correlate well with the streamflow measurements on the Clearwater National Forest, so sediment yields are not presented for these streams.

The second method, in this paper called the time-integration method, ignores streamflow fluctuations and integrates over time. Sediment discharge measured at two consecutive sample dates was averaged and multiplied by the time elapsed between the two hand samples. When a sample taken during high sediment discharge covered a long period (>10 days), the time was adjusted based on what the analyst knew about the position of the sample on the hydrograph and the shape of the hydrograph. This adjustment reflected the tendency for peak flows and high sediment discharges to be short lived.

Research Data

Data were collected in the Silver Creek study area in central Idaho. Streamflow and sediment were measured as described above except that measurements in Silver Creek were taken in a rectangular flume to provide a more uniform cross-section and flow distribution. Sampling was limited to the spring snowmelt period with an average of 15 samples of suspended and bedload sediment each year. The period of record for Silver Creek spring sediment monitoring ranged from 3 to 5 years. These third-order streams drain watersheds of 109 to 186 ha.

Sediment rating equations were developed for suspended, bedload, and total sediment by regression as described for the Forest monitoring data. Sediment yield for Silver Creek streams was computed as above, but in this case mean daily flows were available for each stream.

In addition to the hand sediment samples taken during spring snowmelt, automatic pumping samplers were in operation during most of the year in Silver Creek. Discrete samples were pumped from a hydraulic jump in the flume on a timed basis. The sampler intakes were located 1 to 2 cm from the bottom of the flume to provide an estimate of total sediment load rather than just suspended sediment load. The interval for sampling varied from 1 to 24 hours. The interval was changed manually in response to streamflow changes or precipitation or both. From 26 to 460 samples were taken per stream each year during 4 years. Sediment rating equations were developed from these data as well. The large number of samples made it feasible to group the data by rising and falling limbs of the hydrograph, by storm, and by time, in an attempt to reduce the variance in the data. Sediment yields were estimated using detailed storm-by-storm rating equations, from more general seasonal equations, and by time integrating.

To validate sediment yield estimates from hand samples and pumping samplers, all values were compared with sediment yields from sediment dams located just downstream from the flume in each watershed. The volume of sediment in each sediment dam was converted to mass using volume-weight estimates from core samples of the trapped sediment. This was then corrected for the trap efficiency of the reservoirs. The results are believed to be the

best estimate of actual sediment yield from the watersheds.

RESULTS AND DISCUSSION

Analysis of the data from the Boise and Clearwater National Forests resulted in 87 suspended, 83 bedload, and 81 total sediment rating equations ($Q_s = aQ^b$). Thirty-eight equations of each sediment type were derived from the Silver Creek data.

Rating Equation Success

The number of equations that were statistically significant at the 95 percent level of confidence varied by sediment type (table 1). An arbitrary criterion was used to establish "useful" equations. Equations were used to predict sediment yield if the explanatory (independent) variable, Q, explained at least 60 percent of the variation in the response (dependent) variable, Q_s (that is, $R^2 \geq 0.60$). The better controlled sampling conditions in Silver Creek should have provided data that define the sediment-discharge relation more accurately. However, the variability of sediment discharge was no better defined by the regressions on streamflow in Silver Creek than at the natural cross-sections on the two Forests (table 1).

Significant relationships were much more evident for bedload sediment than for suspended sediment. This supported the observations of Shen (1972), Holeman (1975), and Rannie (1977) that suspended sediment discharge on large rivers was more dependent on watershed properties and perturbations than on streamflow, and that bedload should be more closely correlated with streamflow. Only 11 percent of the suspended sediment equations but half of the bedload equations had $R^2 > 0.60$. Total sediment load rating equations fared much better on the National Forests than in Silver Creek; 78 percent versus 47 percent had $R^2 > 0.60$. The research watersheds were typically smaller than the monitored watersheds on the Forests, but no correlation was found between watershed size and rating equation success.

All suspended sediment regressions in this paper used sediment concentration in milligrams per liter (mg/L) and streamflow in cubic feet per second (ft^3/s). Sometimes suspended sediment is reported as a rate, such as kilograms per hour (kg/h). If this rate is regressed against streamflow, the coefficient of determination will be considerably higher than if the same data in milligrams per liter were used. The result, however, is a spurious self-correlation because the conversion of concentration, milligrams per liter, to a rate in kilograms per hour involves streamflow (Kenney 1982). The regression using kilograms per hour is really aQ vs Q. The self-correlation of Q vs Q does not alter the sediment concentration predicted using streamflow. But a cause-and-effect relationship between the two, with properties of the resulting equation, cannot be claimed.

The rating equations for total sediment were also plagued by spurious self-correlation because suspended sediment concentration must be converted to a rate before being added to the bedload component. This problem is unavoidable with current sampling devices that measure suspended sediment as a concentration and bedload as a rate.

Several factors may contribute to the low success rate for the rating equations. First, the sample size was small, typically 15 or less. With small samples, the table t value becomes large due to the small degrees of freedom. This makes it more difficult to show statistical significance. A related problem may be that the 10 to 15 samples did not adequately sample the hydrograph to define a good sediment-discharge relationship. The hysteresis effect may be inherent in the data, even though there are not enough data points to analyze for these effects. The presence of hysteresis merely adds to the variance due to concentration.

Various levels of management activities existed prior to and during the period of monitoring on most of the Forest watersheds. This could continually vary the sediment supply to the streams such that a good sediment-discharge relationship for a given year may not exist. In the research area, however, management activities were controlled. Most of the drainages were undisturbed for 2 or 3 years and then impacted with specified levels of management. The introduction of disturbances in these small watersheds did not have an adverse effect on the rating equation success. The rating equation success increased slightly after management activities occurred in the drainages. Because these drainages

Table 1—Statistical significance of sediment rating equations in the Idaho batholith

Location	Sediment type[1]	No. rating equations	No. significant rating equations[2]	(%)	No. significant rating equations w/$R^2 > 0.60$	(%)
National Forests[3]	SS	87	38	(44)	10	(11)
	BL	83	59	(71)	47	(57)
	Tot	81	71	(88)	63	(78)
Silver Creek	SS	38	18	(47)	4	(11)
	BL	38	27	(71)	16	(42)
	Tot	38	30	(79)	18	(47)

[1]Type of sediment: SS = suspended; BL = bedload; Tot = total sediment.
[2]Significant rating equations are those with coefficients that are significant at the 95 percent level of confidence.
[3]Data from granitic watersheds on the Clearwater and Boise National Forests, Idaho.

were supply-limited prior to management, the introduction of accelerated sediment could produce a more continuous supply of sediment and actually improve the sediment-discharge relationship.

Channel sediment storage may impact the quality of the sediment-discharge relationships because storage was not accounted for in the equations. Van Sickle and Beschta (1983) discussed the importance of channel bed forms and large organic debris as storage sites for both suspended and bedload sediment. Noting this, they proposed a supply-based model for small streams that uses the suspended sediment rating curve and a supply depletion function. The supply function expresses a declining suspended sediment concentration to reflect storm hysteresis and seasonal decline of sediment supply. Megahan (1982) found an average of 15 times more sediment stored behind obstructions in channels than was delivered to the mouths of the drainages. This suggests that sediment movement is dependent on the dynamics of channel storage components and not just streamflow. It is likely that fluctuations in these storage components during high flows limit the effectiveness of the bedload sediment rating curves.

A more appropriate bedload sediment rating equation should include a constant to define at what streamflow bedload sediment movement is initiated. This plus the introduction of a sediment storage factor might significantly increase the success rate of bedload sediment rating equations.

As mentioned, automatic pumping samplers were used in Silver Creek in addition to the hand samples. Sediment rating equations were developed for these data as well. Six streams with 4 years of record resulted in 23 rating equations. A total of 74 percent or 17 of the equations were significant; only five equations had an R^2 greater than 0.60. The large number of automatic samples made it possible to divide the samples into groups. This was done for rising and falling limbs of the hydrograph around the annual snowmelt peak, for all peaks, and on a seasonal basis. The seasons used were fall (September to mid-November), winter (mid-November to mid-March), spring (mid-March through May), and summer (June through August). These divisions will not be discussed in detail. However, the success rate for these rating equations was: of 278 equations, 62 percent were significant; 24 percent had an R^2 greater than 0.60.

Figure 2 is an illustration of the equations from grouping the data by rising and falling limbs for each peak over a year. The lines labeled 4R and 4F are the rising and falling limb rating curves, respectively, for the snowmelt peak. Curve 1F is a falling limb at the beginning of the water year and is not statistically significant at the 95 percent level of confidence. Curves 2R and 2F represent an early winter rain, 3R and 3F represent a February thaw, and 5R and 5F result from spring rains.

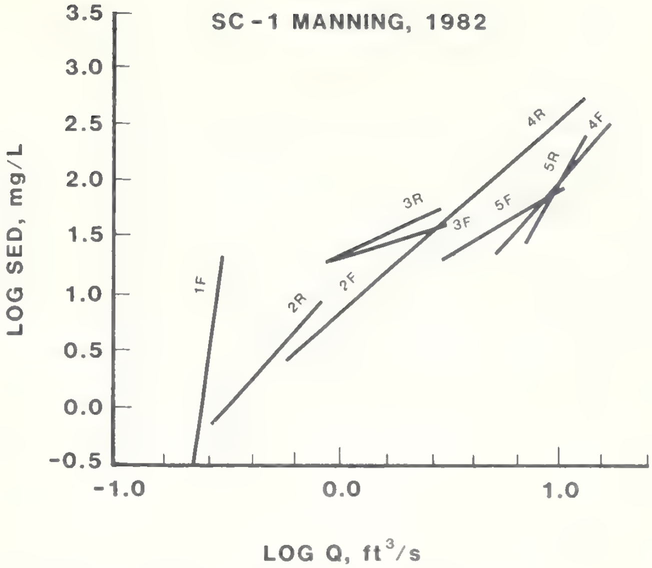

Figure 2—Suspended sediment rating curves based on individual rising and falling limbs of an annual hydrograph. R = rising; F = falling; numerals indicate chronological order of the hydrograph peaks. The extent of the curves indicates the limits of the data.

Documenting Management Effects

Previous analyses have indicated that floods and management activities cause shifts in suspended sediment rating equations (Flaxman 1975; Rosgen 1980). In the handbook, "An Approach to Water Resources Evaluation of Non-point Silvicultural Sources," Rosgen (1980) presented one such analysis for the Needle Branch watershed in Oregon. Rating curves shifted following the 1964 flood and subsequent clearcutting operations. No statistical information was presented regarding the significance of the observed changes in the rating equations. In the following examples from the Idaho batholith, the influence of management on both suspended and bedload sediment rating equations will be discussed in terms of statistical significance.

In Silver Creek, 38 ha were harvested on south aspects in watershed SC-6 (163 ha). The units were clearcut and yarded by helicopter in the fall of 1976. The following year was extremely dry and no instream sediment was sampled, so 1978 is the first posttreatment year for which sediment rating equations were developed. The suspended sediment rating equations (fig. 3a) indicate that a shift to a steeper slope may have occurred between 1976 and 1978. However, the two curves are not statistically different at the 95 percent level of confidence. No statistical change in sediment yield occurred at the sediment dam following the timber harvest.

The only curve in figure 3a that is statistically different from any of the others is the 1982 curve. It differs from both the 1975 and 1980 curves in slope

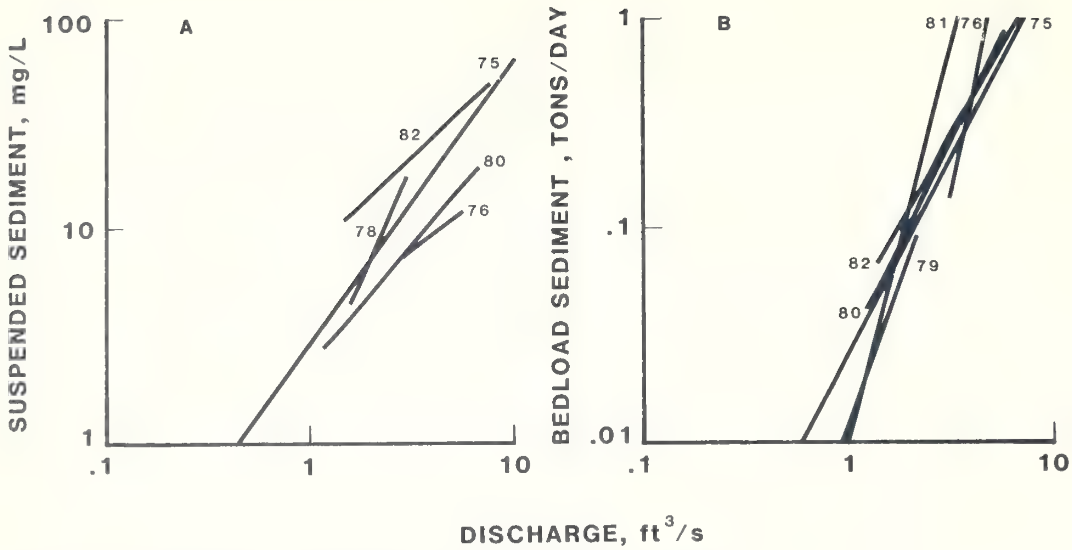

Figure 3—Sediment rating curves for stream SC-6 in the Silver Creek study area. The extent of the line indicates the limits of the data.

only. Interestingly, it is not significantly dif erent from the 1978 curve due to high variability The shift in the 1982 suspended sediment curve does coincide with a statistically significant increase in sediment yield at the sediment dam. This delayed sediment yield increase at the mouth of watershed SC-6 is likely due to sediment storage along the channel with a subsequent release of the stored material by greater than normal spring runoff in 1982. In this case, the change was documented through a shift in the rating equation. However, it is not likely that the stream would be sampled for 6 years under normal monitoring programs on the typical forest.

The bedload curves for the stream in watershed SC-6 (fig. 3b) show two distinct groupings: the 1976, 1979, and 1981 curves appear to be a separate group from the other three in terms of slope. The only statistical differences are that the slope for 1979 is different from 1975 and 1982. The 1978 data do not produce a significant equation. Although the 1981 curve is statistically significant, the variance about the equation is large, resulting in wide error bands. This explains why it does not test significantly different from the other equations. Any effect the timber harvest had on the bedload rating equations is not discernible.

During the summer of 1980, a kilometer of road construction within proximity of the stream channel in watershed SC-4 (102 ha) was completed. The rating equations appear to shift in response to this (figs. 4a and 4b). The 1981 rating equations for both suspended (fig. 4a) and bedload (fig. 4b) sediment are significantly different from the rest of the years. The 1981 suspended sediment curve differs only in slope, while the bedload curve differs both in slope and intercept. The 1982 curves suggest a recovery to near preroad construction conditions, despite continued sediment delivery to the channel from the road that year.

Bedload sediment rating equations for the stream in watershed SC-2 (118 ha) show a significant slope reduction between 1979 and 1980 with apparent recovery in 1981 and 1982 (fig. 5). There was no management activity in this drainage during this time. Suspended sediment rating curves are not shown because only one equation from 5 years of record was significant.

Documenting management effects on sediment rating equations from the two Forests was more difficult because records of exactly when the activity occurred were not readily available. The date when the contract was awarded was available, but the actual operation may have taken place a year or more later. For this reason, an analysis of Forest data with respect to management effects on rating equations is not presented here.

The problems encountered above may be due more to the data than to rating equations in general. However, the data used in the above analyses are typical of sediment data collected on National Forests in the Intermountain West. Shifts in sediment rating curves based on small sample sizes may result from differing ranges of streamflow over which data are collected from year to year. This is somewhat unavoidable depending on the range of flows present each year. However, sampling should encompass the same range of flows as much as possible each year. Otherwise, being on a different portion of the logarithmic curve could provide a different equation. The change in curves may also result when sample variance is high and small sample sizes do not adequately sample the variance. A third reason for change in curves is a real change in the sediment-discharge relationship.

Using sediment rating equations as the sole evidence for management impacts is not advised. The effects of sample size and sampling scheme on the equations may not be completely separable from the effects of management on the sediment-discharge relationship. Few if any forests will be able to collect enough samples to alleviate

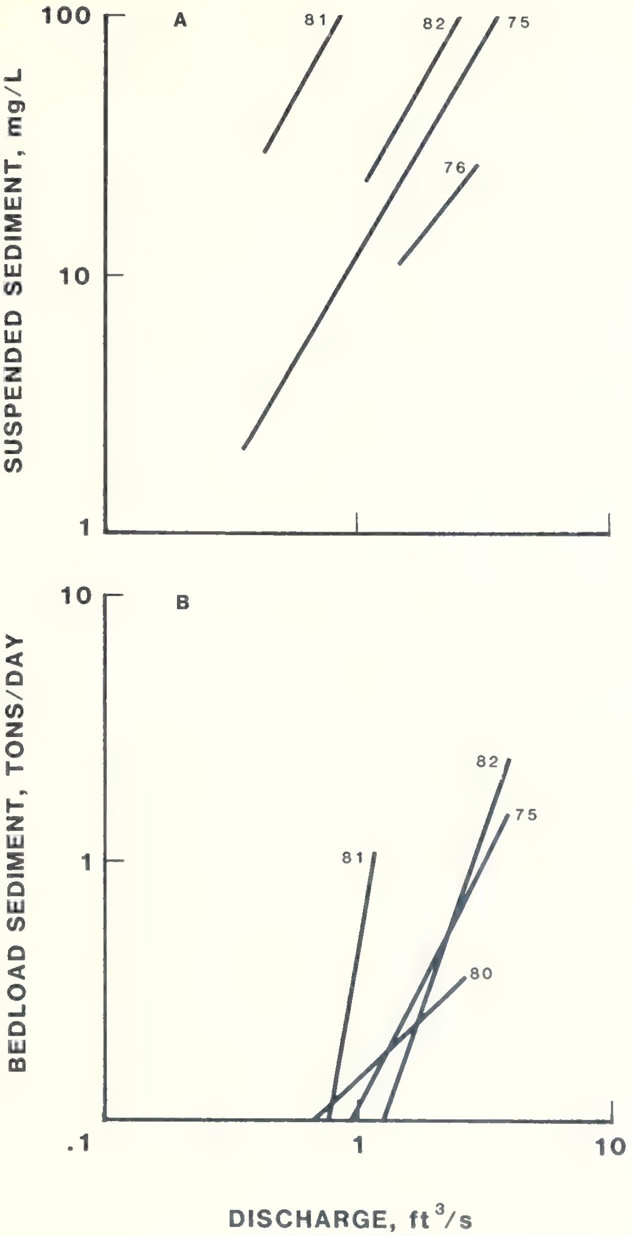

Figure 4—Sediment rating curves for stream SC-4 in the Silver Creek study area. The ends of the curves indicate the limits of the data.

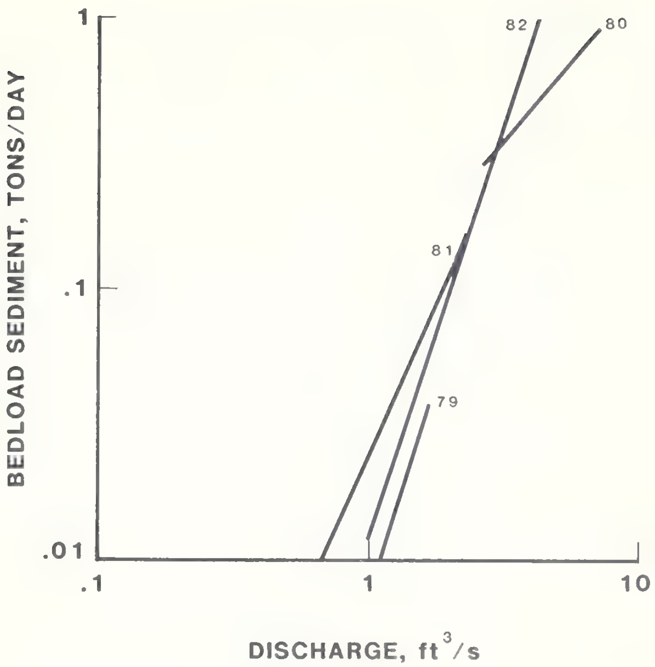

Figure 5—Bedload sediment rating curves for stream SC-2 in the Silver Creek study area.

the statistical problems surrounding small, variable sample sets. However, if used with other forms of evidence, a rating equation may provide valuable, additional documentation.

Sediment Yield Estimation

One of the basic purposes for developing a sediment rating equation for a stream is to estimate sediment yield. The sediment rating equation is used to predict an appropriate sediment rate for periods when no sediment data are available but streamflow is available or can be accurately estimated. For sediment yield estimates in this paper, mean daily streamflow values were used with the sediment rating equations. Streamflow for the monitored streams on the Boise National Forest was derived from U.S. Geological Survey gauging stations in the vicinity. Continuous streamflow records were available for the streams in Silver Creek.

The two methods used to estimate sediment yield for streams on the Boise National Forest yielded somewhat different results (fig. 6). The time-integration technique typically yielded higher values than the rating equation approach. A paired *t* test showed that the difference between the two methods was significant at the 95 percent level of confidence. Because there was no known true value for sediment yield from these watersheds, no evaluation of which estimate was more accurate could be made.

The time-integration method probably averages higher because samples taken at or near peak sediment movement are generally averaged over longer periods than may be appropriate for that level of sediment transport. Timing of the samples is important because a single sample must be representative of the prevailing conditions, in some cases for many days. The rating equation is also affected by the timing. However, the effect may not be in the same direction or be as significant for the rating equation because all sample points are analyzed as a group. Each sample carries more weight in the time-integration method. Walling (1977) discovered gross overestimates of total load using sediment rating curves for three British rivers. However, monthly suspended loads were both overestimated and underestimated based on rating equations, with overestimates predominating.

Sediment dams at the mouths of streams in the Silver Creek study area provided a base sediment yield estimate to compare with estimates from different methods.

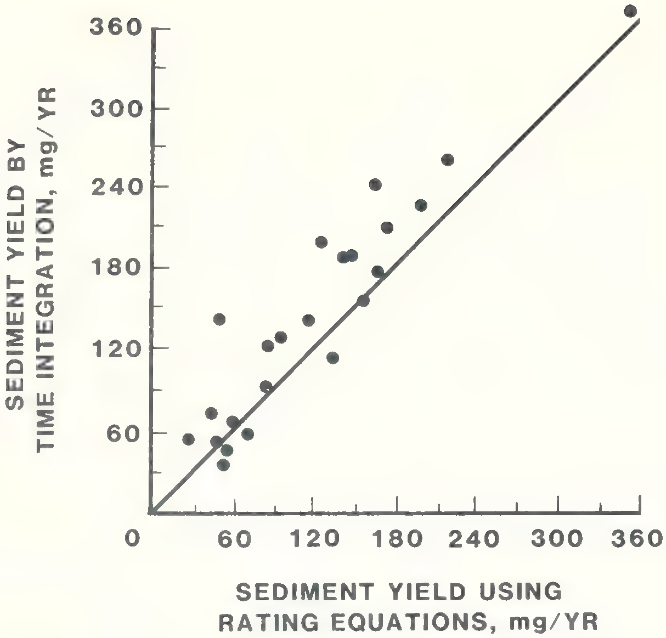

Figure 6—Comparison of sediment yield estimates from two methods: (1) by using sediment rating equations and (2) by time-integration between hand samples. Data from stream monitoring on the Boise National Forest.

Five estimates of sediment yield were made from the data in Silver Creek (table 2). The first method used a sediment rating curve for total sediment from the hand samples and mean daily streamflow. The second method time-integrated total sediment as described above for the Boise National Forest data. The third and fourth methods were the same as the first two with the exception that the automatic pumping sampler sediment data were used. The fifth method estimated sediment yield based on the volume of sediment in sediment dams.

The equivalency of the rating equation method and integration method for the hand samples was tested with a paired *t* test. The hypothesis that the two methods give the same estimates was accepted at the 95 percent level. However, as with the Forest monitoring data, the time-integration method averaged slightly higher yields than the rating equation method (fig. 7). The sediment yields from these two methods are compared with the sediment dam yields (fig. 8), and neither tested different from the sediment dam yields at the 95 percent level. But the yield estimates from the rating equations did test different at the 90 percent level. Although the differences were not significant by the paired *t* test, the sediment dam yields were somewhat less for years of low sediment yields and greater for high sediment years than the estimates by rating curves and integration. The paired *t* test only tests the means, so the variances could be different.

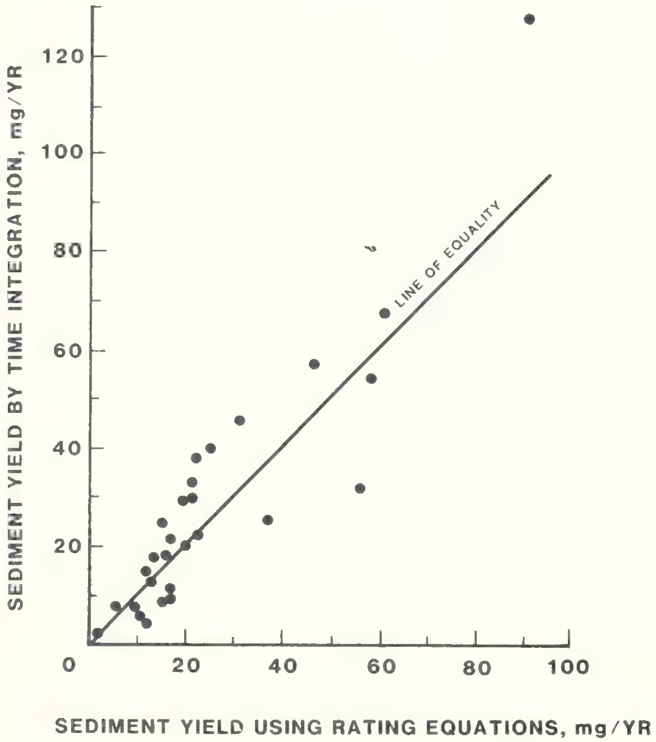

Figure 7—Comparison of total sediment yield estimates from two methods: (1) by using sediment rating equations and (2) by time-integration between hand samples. Data from streams in the Silver Creek study area.

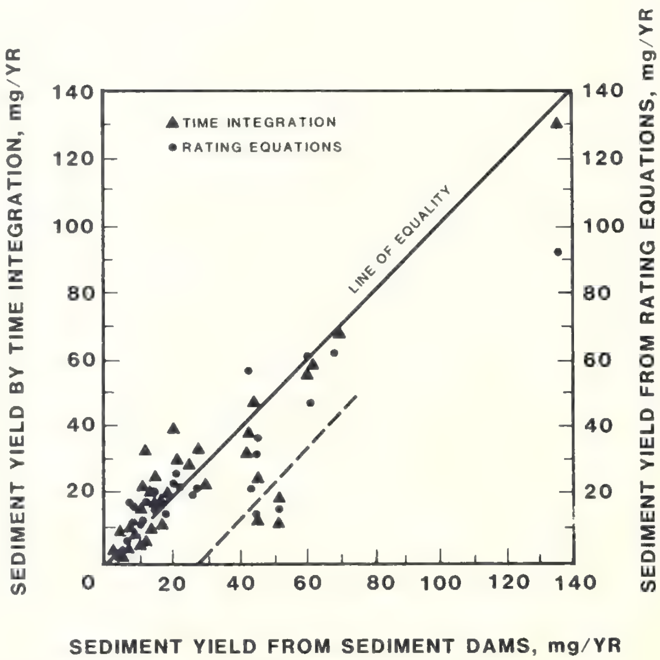

Figure 8—Comparison of sediment yield estimates using time-integration, rating equations, and sediment dams from Silver Creek data.

Table 2—Comparative sediment yields for Silver Creek streams, Idaho

Stream	Year	Total sediment yield estimates in megagrams per year				
		Hand samples		Sediment dam yield	Pumped samples	
		Rating equations	Time integration		Rating equations	Time integration
SC-1	78	13.8	17.1	16.8		
	79	5.4	7.3	5.3	1.9	2.1
	80	31.2	45.3	44.6		
	81	16.2	10.7	15.4	5.3	3.4
	82	46.9	57.2	61.1		
SC-2	78	16.7	9.3	7.2		
	79	1.5	1.5	3.4	.7	.6
	80	22.0	38.0	42.8	5.6	1.2
	81	10.3	5.3	9.3	2.1	2.5
	82	59.0	54.3	60.1		
SC-3	75	20.1	19.8	14.4		
	76	16.7	20.9	11.4		
	78	—	8.9	11.9		
	79	—	1.6	2.9	2.2	.6
	80	14.9	24.8	14.1	1.5	4.1
	81	11.1	4.4	7.3	1.6	2.6
	82	56.2	31.8	41.8		
SC-4	75	22.7	21.3	19.3		
	76	—	22.0	27.8		
	78	—	11.2	50.4		
	79	—	2.6	4.5	1.0	.7
	80	15.6	18.0	50.6	8.7	14.4
	81	12.5	12.0	43.5	7.0	16.6
	82	91.1	128.6	135.9		
SC-5	75	—	32.3	12.1		
	76	—	18.9	17.4		
	78	—	15.0	13.6		
	79	—	1.3	2.7	1.6	1.9
	80	11.8	14.3	10.6	11.9	13.7
	81	15.2	8.8	8.5	2.9	4.8
	82	36.8	24.9	44.4		
SC-6	75	19.4	28.7	25.6		
	76	21.1	32.6	26.9		
	78	21.0	29.5	21.0		
	79	1.5	1.9	3.5	1.5	1.2
	80	25.3	39.8	20.8	10.3	12.0
	81	9.5	7.4	9.1	4.3	3.1
	82	61.2	67.9	68.9		

The large variance associated with sediment data may have masked differences in estimates from various techniques, but the differences did exist. Only 26 percent of the time-integration estimates and 21 percent using rating equations were within 10 percent of the sediment dam estimates. Table 3 shows that nearly 50 percent of the estimates were within the 25 percent error band, but also that some estimates were 100 percent or more different.

Several factors were used to try to explain why some sediment yield estimates from rating equations were within 10 percent of "actual" while others were more than 50 percent different. These included the number of samples on the rising versus the falling limbs of the hydrograph, statistical significance of the suspended sediment and bedload equations, and the sample year.

Table 3—Percentages of sediment yield estimates within specified error bands around the sediment dam estimates

Percent error	Percent of estimates within given error	
	From rating equations	From time integration
10	21	26
25	55	45
50	76	74
80	97	92
100	97	97
150	100	97
200		100

No trends were established, and it appeared that it was a matter of chance that the sediment yield estimates were close to the sediment dam yields. The most severe underestimation of sediment yield by both methods was for the first 2 years after road construction in watershed SC-4 and for years of high annual water yield in some watersheds. These are the data points below the dashed line in figure 8. This was probably the result of too few samples to accurately define the sediment-discharge relationship following disturbance and at times of active channel bed movement. During higher than normal streamflow, channel sediment storage features may break up and re-form. This may release pulses of sediment that were not measured by weekly or every-other-day sampling. This again points out the importance of storage in these high-energy third-order streams.

Because the time-integration method appears to estimate sediment yield as well as the rating equations but does not require continuous or mean daily flow records, this method is probably more desirable for use on ungauged streams and on gauged streams where good sediment rating equations cannot be developed. This conclusion is based on the results from the Silver Creek research watersheds just discussed. The same conclusion cannot be reached for the data from the Forests because there is no known value to check against. To make the time-integration method work, samples must be well distributed over the entire hydrograph so that highs as well as lows are sampled. Streams in Silver Creek were generally sampled every other day during snowmelt with a morning sample one time and an afternoon sample the next time. In this way not only the general hydrograph was sampled, but daily hydrograph variations were accounted for such that, by averaging the sediment rates of two consecutive samples, near average conditions were simulated. If all samples were taken near hydrograph peaks, sediment yield would be overestimated. On the other hand, if peak flows were not sampled, sediment yield would be underestimated. Poor sampling will provide erroneous estimates of sediment yield.

The number of samples necessary to characterize a hydrograph depends on flow conditions. In snow-dominated systems typical of the Northern Rocky Mountains, the majority of sediment transport occurs during spring snowmelt. This may be completed in 3 or 4 weeks one year and 6 or 8 weeks the next year. Generally, sampling during this melt period is sufficient to predict annual sediment, particularly in bedload-dominated systems, because this is the major time that streamflow is sufficient to transport bedload. Where suspended sediment is more important, samples may be required throughout the year because suspended sediment may frequently be mobilized during summer storms. Management impacts may produce readily available sediment that may be transported during the summer as well. This should be considered in sample collection planning.

The sediment yield estimates, based on the pumped samples and DH-48 hand samples, gave differing estimates, and these estimates are quite different from the sediment dam estimates (table 2). Pumping samplers are designed for sampling suspended load, but the intakes for these samplers in Silver Creek were in a hydraulic jump 1 to 2 cm from the bottom, in an attempt to sample bedload as well. Because of the large percentage of suspended sediment rating equations that were not significant, a comparison of suspended sediment yield from DH-48 samples and pumped samples was done using the time-integration method estimates (table 4). The correspondence of the paired sediment yield estimates was variable, but a paired *t* test indicated that the pumping sampler estimates were significantly higher than the hand samples at the 90 percent level. This suggested that because of the intake position, the pumping samplers were indeed sampling more than just the suspended sediment load of the streams. However, the pumping samplers were not fully sampling total sediment when compared with the sediment dams (table 2).

The detailed analysis of rising and falling limbs of the hydrograph for the pumped samples did not provide enough significant rating equations to model each storm event during the year. Also, many of the significant equations that resulted from five to 10 samples on a rising or falling limb covered such a narrow range of discharge that extreme caution was necessary when predicting sediment. So narrow were many of these discharge ranges that the equation was not useful for prediction. This was probably because the relationship between the five to 10 sediment concentrations and discharges had a high variance, and therefore the true line may have been much different. Many of these relationships had extremely low coefficients of determination. Less than half the significant equations had coefficients of determination of 0.60 or more. The best results were achieved by dividing the data set at the annual snowmelt hydrograph peak or by season. In some years the most useful relationship resulted from using the entire data set.

Table 4—Comparison of suspended sediment yield estimates using DH-48 hand samples and automatic pumping sampler samples

Stream	Year	Sediment dam yield	Sediment yield by time integration: DH-48	Pumping sampler
		Megagrams per year		
SC-1	79	5.3	1.9	2.1
	81	15.4	4.9	3.4
SC-2	79	3.4	.5	.6
	80	42.8	6.1	1.2
	81	9.3	2.1	2.5
SC-3	79	2.9	.6	.6
	80	14.1	2.7	4.1
	81	7.3	2.6	2.6
SC-4	79	4.5	.9	.7
	80	50.6	7.2	14.4
	81	43.5	6.1	16.6
SC-5	79	2.7	.4	1.9
	80	10.7	2.1	13.7
	81	8.5	1.8	4.8
SC-6	79	3.5	1.1	1.2
	80	20.8	12.7	12.0
	81	9.1	2.4	3.1

As discussed earlier, annual sediment yields from total sediment rating equations were found to average less than the sediment dam yields at the 90 percent confidence level but not at the 95 percent level. Total sediment yield was also estimated by determining annual suspended sediment and annual bedload from the respective suspended sediment and bedload rating equations and adding the results. These estimates were somewhat less than those from the total sediment rating equations (fig. 9) and tested significantly less than the sediment dam estimates at the 95 percent confidence level. This data set, however, was smaller (n=17) than the earlier data set (n=29) because there were fewer years when both the suspended sediment and bedload equations were significant.

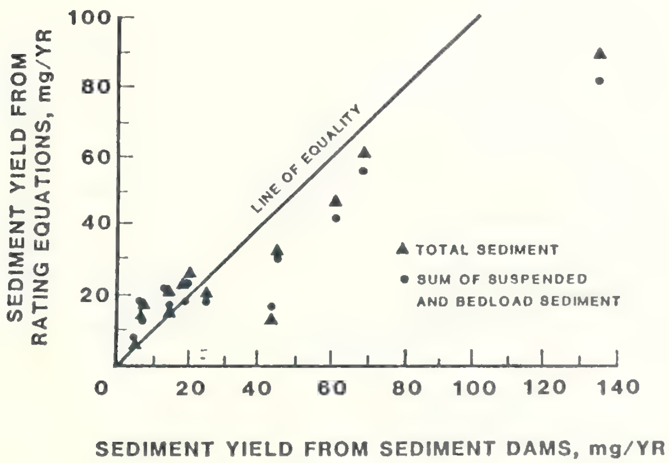

Figure 9—Comparison of sediment yield from sediment dams with sediment yield from total sediment rating equations and the sum of yields from suspended and bedload sediment rating equations. Data from Silver Creek watersheds.

CONCLUSIONS

Sediment rating equations similar to equation 1 that are based on small sample sizes are not in themselves reliable for documenting watershed disturbances in streams dominated by bedload sediment in the Idaho batholith. A large proportion (33 percent) of the rating equations developed during this evaluation were not statistically significant, and an additional 24 percent, while significant, were not "useful" because streamflow explained less than 60 percent of the variance in sediment. Year-to-year watershed response evaluations were extremely difficult. The large natural variance of sediment data resulted in rating equations with wide confidence bands. This made it hard to show statistical significance of suspected shifts in rating equations. Rating equations for a given stream changed from year to year. Sometimes the change could be attributed to activities in the watershed, but other times there was no apparent reason for the shift. It may have resulted from the sampling scheme or purely from sample variance.

In snowmelt-dominated and bedload-dominated systems, time integration of sediment yield from sample date to sample date can provide accurate estimates of annual sediment yields with as few as 15 or 20 well-taken samples. This requires that samples adequately describe the average conditions for which they apply. Misleading estimates of sediment yield will be obtained if sampling does not properly reflect streamflow and sediment transport distributions. Sampling schedules should be well thought out and flexible so that atypical runoff events can also be sampled. Thus, accurate sediment yield estimates can be expected using time integration. For the Silver Creek data, 74 percent of the estimates of sediment yield by time integration were within 50 percent of the sediment dam yields.

The use of pumping samplers to generate more samples does not necessarily increase the chances of having better predictive rating equations. Of the rating equations developed for pumped samples in Silver Creek, 62 percent were significant, and many of the significant equations had limited usefulness for predictions due to the small range in streamflow for which they applied. Pumping samplers with intakes positioned as those in Silver Creek do not adequately provide total sediment load samples. When placed close to the bottom of the stream they will sample some bedload but only enough to overestimate suspended sediment load.

Separate suspended and bedload sediment rating curves estimate smaller sediment yields than do the total sediment rating equations from the same data. Total suspended sediment equations appear to estimate too much sediment for low annual yield years, and increasingly too little sediment for greater sediment years.

REFERENCES

Anderson, Henry W. Relative contributions of sediment from source areas and transport processes. In: Present and prospective technology for predicting sediment yield and sources: Proceedings, sediment yield workshop; 1972; Oxford, MS. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service; 1975: 66-73.

Emmett, W. W. The channels and waters of the Upper Salmon River area, Idaho. Professional Paper 870-A. Washington, DC: U.S. Geological Survey; 1975. 116 p.

Flaxman, Elliott M. The use of suspended-sediment load measurements and equations for evaluation of sediment yield in the West. In: Present and prospective technology for predicting sediment yield and sources: Proceedings, sediment yield workshop; 1972; Oxford, MS. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service; 1975: 46-56.

Holeman, John N. Procedures used in the Soil Conservation Service to estimate sediment yield. In: Present and prospective technology for predicting sediment yield and sources: Proceedings, sediment yield workshop; 1972; Oxford, MS. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service; 1975: 5-9.

Idaho Water Resources Board. Idaho water resources inventory, water resources planning studies. Moscow, ID: Water Resources Research Institute, University of Idaho; 1968. 598 p.

Kenney, Bernard C. Beware of spurious self-correlations! Water Resources Research. 18(4): 1041-1048; 1982.

Livesey, Robert H. Corps of Engineers methods for predicting sediment yields. In: Present and prospective technology for predicting sediment yield and sources: Proceedings, sediment yield workshop; 1972; Oxford, MS. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service; 1975: 16-32.

Megahan, Walter F. Channel sediment storage behind obstructions in forested drainage basins draining the granitic bedrock of the Idaho batholith. In: Swanson, Frederick J.; Janda, Richard J.; Dunne, Thomas; Swanston, Douglas N., tech. eds. Sediment budgets and routing in forested drainage basins. General Technical Report PNW-141. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1982: 114-121.

Rannie, W. F. An approach to the prediction of suspended sediment rating curves. In: Proceedings of 5th Guelph symposium on geomorphology. Norwich, England: Geo Abstracts LTD; 1977: 149-167.

Rosgen, David L. Chapter VI. Total potential sediment. In: An approach to water resources evaluation of non-point silvicultural sources (a procedural handbook). EPA-600/8-80-012. Washington, DC: U.S. Environmental Protection Agency; 1980: VI.1 - VI.43.

Shen, H. W. Total sediment load. In: Shen, H. W., ed. River mechanics. Fort Collins, CO: Colorado State University; 1972: 13.1-13.26.

Strand, Robert I. Bureau of Reclamation procedures for predicting sediment yield. In: Present and prospective technology for predicting sediment yield and sources: Proceedings, sediment yield workshop; 1972; Oxford, MS. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service; 1975: 10-15.

Van Sickle, John; Beschta, Robert L. Supply-based models of suspended sediment transport in streams. Water Resources Research. 19(3): 768-778; 1983.

Walling, D. E. Limitation of the rating curve technique for estimating suspended sediment loads, with particular reference to British rivers. In: Erosion and solid matter transport in inland waters: Proceedings; 1977 July; Paris, France. IAHS Publication No. 122. International Association of Hydrological Sciences; 1977: 34-48.

Ketcheson, Gary L. Sediment rating equations: an evaluation for streams in the Idaho batholith. General Technical Report INT-213. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 12 p.

Sediment data from streams in the Idaho batholith were used to develop suspended, bedload, and total sediment rating equations. These equations are discussed in terms of statistical significance and their usefulness for documenting management impacts. Sediment yields were estimated using the rating equations and streamflow data. These yields were compared with those estimated from a time-integration method. For streams in the Silver Creek research area, sediment yields from rating equations and time-integration techniques were compared with estimates from sediment dams. Rating equation and time-integration estimates were statistically different. Time-integration estimates more closely matched those from the sediment dams.

KEYWORDS: rating equations, sediment, sediment yield, suspended sediment, bedload

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The Genesis of FORPLAN: A Historical and Analytical Review of Forest Service Planning Models

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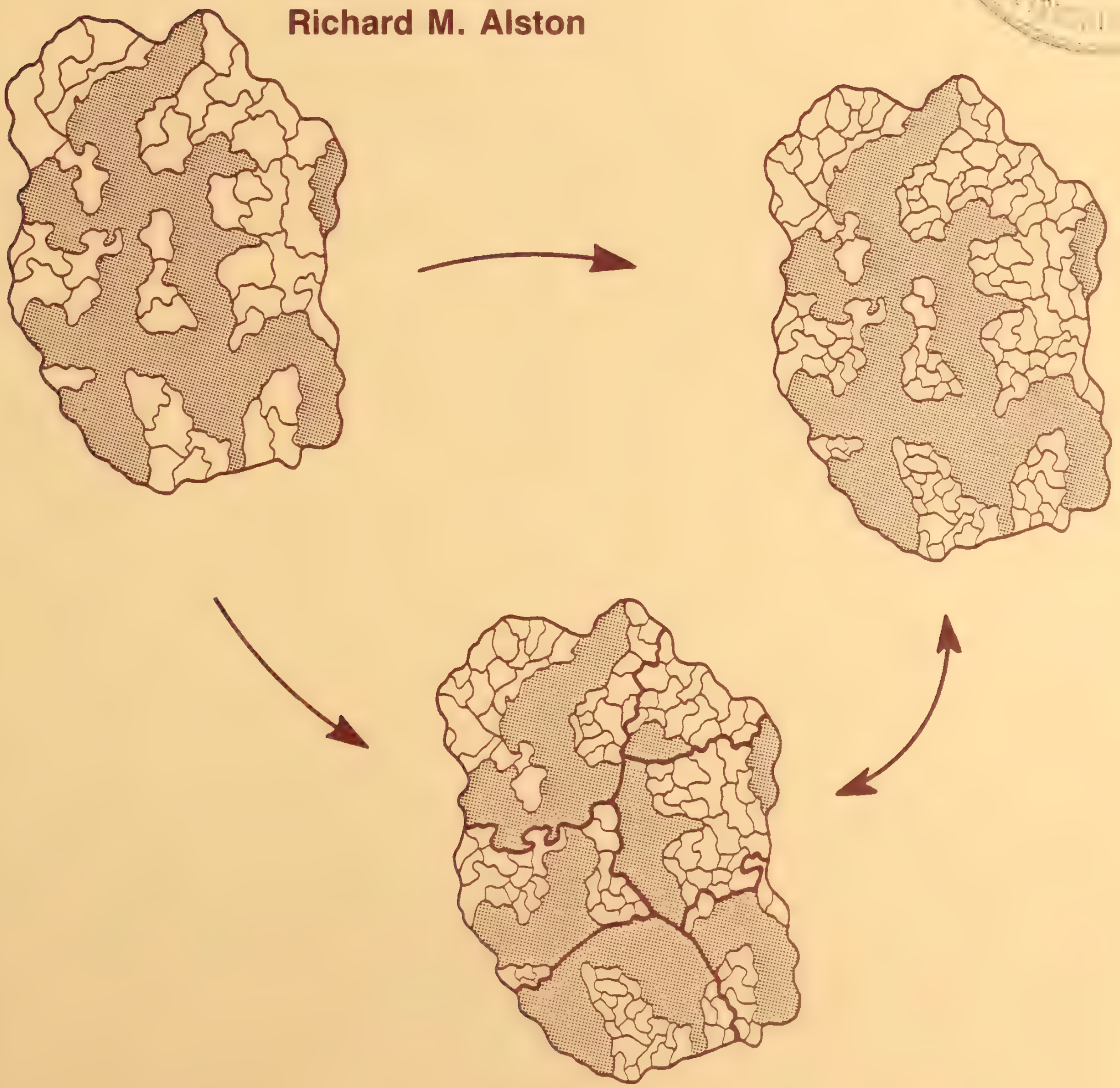

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RESEARCH SUMMARY

The art of forest management planning in the Forest Service, U.S. Department of Agriculture, has evolved at a fever pitch pace in the past three decades. The most important changes that influenced planning include rising demands for all products of the forest, environmental activism, environmental laws, and land management legislation. The movement has been away from independent and functional analysis toward multidisciplinary, then integrated evaluation of all functions and alternative actions in the context of ecosystem management. Comprehensive changes in the tools of analysis were needed. From the late 1950's through the 1970's several computer models were developed, including the Timber Resource Allocation Method (Timber RAM), which was the foundation for subsequent improvements, and the Multiple Use-Sustained Yield Calculation Technique (MUSYC).

The FORest PLANning model (FORPLAN), evolving from Timber RAM, bridged the gap between functional resource planning and integrated land management planning. Contrasted to earlier models, FORPLAN was capable of analyzing much more sophisticated and complex questions concerning the interactions among the forest resources. It placed greater emphasis on integrating site-specific analysis with forestwide allocation and on scheduling an array of multiple-resource activities through time. The rapidly changing social, political, and legal environment demanded an even more integrated approach. With the resulting FORPLAN Version 2, the user can relatively easily specify the temporal and spatial aspects of identified problems. A major drawback is the ability of users to hide assumptions and the tendency to analyze a limited range of management strategies.

This study traces the historical development of models that eventually led to the use of FORPLAN by the Forest Service, and traces the shift from traditional single-resource scheduling to interdisciplinary, integrated, multiresource management planning.

CONTENTS

The Genesis of FORPLAN: A Historical and Analytical Review of Forest Service Planning Models

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Richard M. Alston

INTRODUCTION

Planning for efficient use of the Nation's renewable resources has been long debated. The FORest PLANning Model (FORPLAN) and other sophisticated computerized models are currently used by the Forest Service in the development of land and resource management plans. The development of FORPLAN, like many other computerized systems, progressed rapidly. The present and future generations of land management planners and foresters alike might better perform their jobs if they understand the historical and evolutionary context of their tools and policies. This paper traces the development of the FORPLAN analytical tool with the parallel organizational development of decision making for land management planning in the Forest Service, U.S. Department of Agriculture. FORPLAN utilizes linear programming (LP). Much of our discussion centers on FORPLAN and use of other linear programming models for land management decision analysis.

Several themes are woven into the story of the evolution of the use of computer models in land management planning:

—Gifford Pinchot, the Forest Service's first Chief, emphasized wise use and planning as a means to ensure that resources would be used for the benefit of the whole Nation while at the same time preserving the productivity of the forests. That philosophy runs throughout the history of the Forest Service right to today and has remained intact despite the presence of changing issues.

—The tools needed in land management planning changed as the issues changed. The issues that changed involved the rising demands for forest products, environmental activism, environmental legislation, and land management legislation.

—Land management planning has moved away from independent and functional analysis toward, first, multidisciplinary, then integrated interdisciplinary analysis of all natural resources and uses of land. Consequently, planning has gradually shifted from a single-resource emphasis to an integrated multiresource emphasis.

—The new tools for planning made it increasingly feasible to plan in terms of both space and time, not just one or the other.

—The new tools enabled a greater emphasis on integrating site-specific analysis with forestwide allocation. Comprehensive planning of land use is now possible.

This paper's first section provides an overview of early attempts to build effective models supporting forest resource allocation decisions. Several models are introduced in their chronological order to create a context for the evolution of subsequent developments. The second section provides a more detailed look at three models—Timber RAM, MUSYC, and FORPLAN. Here we present a general discussion of questions that fostered model development and critically evaluate the limits inherent in the model structures. The third section, summary and conclusions, provides some general considerations and speculates on expected future use of computerized mathematical programming models in the context of land use planning. Appendix I presents the essential elements of linear programming, including a simple example. It is intended to provide the uninitiated with a framework for understanding the discussion in the second section. Those who have a strong background in linear programming may choose to skip this section. Appendix II provides a mathematical exposition of the various model structures discussed throughout the paper. The last appendix is a glossary.

SECTION I: HISTORICAL OVERVIEW

As a result of considerable ferment centering around a discussion of forest practices, Congress enacted on March 3, 1891, the General Revision Act, Section 24 of which has come to be known as the Creative Act of 1891. As later amended, the Act created forest reserves that were renamed National Forests in 1907. The passage of the Organic Act of 1897 and the Transfer Act of 1905 created both the agency—the Forest Service, U.S. Department of Agriculture—and the basic governing code that was to guide management of the National Forests for the next eight decades.

Today the Forest Service is responsible for the management of 191 million acres of forest land that annually produces an estimated 12 billion board feet of timber, 10 million animal unit months of grazing, 425 million acre-feet of water, 200 million recreation visitor days, and many other valuable outputs and environmental benefits. The responsibilities have evolved from custodial protection to intensive integrated management on an unprecedented scale. As demands placed on the resource base increased, so too did managerial demands for effective support in research, administration, and planning.

Planning is Not New

Forest planning is an ancient art. Professional forest regulation emerged in Germany in an attempt to ensure that the goals of management could be accomplished as fully as possible. The German influence on American forestry was evident both in practical application and underlying ideology (Alston 1983). Emphasis on forest planning was ensured when Gifford Pinchot became Chief of the Division of Forestry in 1898. In a publication addressed to the users of the National Forests (USDA-FS 1907, p. 25), Pinchot spelled out the essential elements of the multiple-use local planning idea that would dominate American forest policy in subsequent years:

> National Forests are made for and owned by the people. They should also be managed by the people. . . . This means that if National Forests are going to accomplish anything worth while the people must know all about them and must take a very active part in their management. . . . There are many great interests on the National Forests which sometimes conflict a little. They must all be made to fit into one another so that the machine runs smoothly as a whole.

Pinchot's view that forest conservation should include wise use and, when appropriate, protection from overuse as well as long-term preservation of the productivity of the forest reserves was to be implemented through planning. His influence has endured to the present. As Wilkinson and Anderson (1985, p. 23) have argued:

> Pinchot required planners to prepare detailed inventories, monitor the condition of the reserves, determine sustainable use levels, and exclude use from specific areas where necessary to protect the watershed and other resources. These four features were hallmarks of Pinchot's conservation planning. They became a fundamental part of Forest Service policy and in the 1970's received Congress's imprimatur in the NFMA [National Forest Management Act].

In 1911, under the direction of Chief Forester Henry S. Graves the Forest Service published The National Forest Manual (USDA-FS 1911) containing specific instructions to forest officers relating to the need for detailed forest plans to carry out the mission of the Agency. Three types of plans, differing only in scope and intensity, were identified: preliminary plans, working plans, and annual plans. The forest plans were to coordinate the various lines of work and provide for the most efficient administration and the best use of the forest resources possible at the least practicable cost. Where necessary the forest was divided for planning purposes into areas called "working circles," each of which would be managed for sustained yield. Timber management plans were to consider both biological and economic conditions. Final responsibility in the preparation of all forest plans rested with the Forest Supervisor, who would also be responsible to ensure that all preliminary or working data be kept on file for subsequent review. The emphasis in 1911 was on silvicultural management and data collection, but grazing, water, and other uses of the forest were also given attention.

The end of the first decade of this century saw the emergence of the themes that run throughout the history of Forest Service planning and that provide the cement binding the facts and events into a meaningful story. Functional planning emphasizing the characteristics of each major forest resource and its uses (timber, range, watershed, and so forth) would have to be technically accurate. But at the same time, resource specialists would have to realize that the forests—these systems within systems—could not be effectively managed or understood except in a holistic, interdisciplinary context. Emphasis on site-specific characteristics, such as soils, habitat type, and biological and social stability, would be necessary to allow for the adaptation of general principles of forest management to local conditions. Nevertheless, decentralized plans and decisions would have to be coordinated with actions taken in the Washington Office to ensure that local and national priorities fit within an overall framework compatible to both needs.

During the 1920's timber management plans for working circles large enough to support local forest-based industries were prepared, and range allotment plans complete with maps and seasonal restrictions covered some 70 percent of approximately 7,000 allotments. Budgetary and financial plans to guide day-to-day operations were a major effort, and even some watershed, recreation, and wilderness plans were completed (Wilkinson and Anderson 1985).

By 1933 the concept of multiple use had been broadened beyond commodity uses of the forest to include outdoor recreation, wildlife habitat, environmental amenities, and esthetics (Towle 1982; Alston 1983). Emphasis was shifting from local and forest-level planning to national issues (Cameron 1928). The so-called Copeland Report (U.S. Congress, Senate 1933) broke with past practices of the Forest Service and the past justification of forestry itself. It called for a more flexible multiple-purpose management planning process that reflected national economic conditions. In light of the agricultural depression, this shift of emphasis toward community stability and employment opportunities is not surprising. The view that it is the responsibility of government to promote both local and national goals through land management planning became one of the enduring themes of public land policy. That the concept of national planning is controversial, then as now, is documented in Steen (1977) and Wilkinson and Anderson (1985). As Arthur Newton Pack (1933, pp. 160-161) saw it:

> Forest planning based on an hitherto untried scale - on a national scale - is needed now. A coordinated integration of forestry within the national scheme as a major agency of land use, based on adequate knowledge of conditions and backed by vigorous and effective leadership, is required along a united front wherein our land, administrative agencies both public and private, shall fit in and perform their allotted tasks.

For the next 20 years forest policy and planning were in flux. The 1930's concept of multiple use had not yet become strong enough to overwhelm the historical emphasis given commodity uses of the forest, especially

timber, water, and range (McCloskey 1961; Alston 1972). Nor was it strong enough to alter Agency planning and decision-making processes that continued along traditional functional lines, with emphasis on local and regional concerns. Indeed, planning was sometimes little more than calculations made by District Rangers and Forest Supervisors on the backs of envelopes. Activity scheduling often consisted of recording in their ever-present Use Books how they hoped to implement the plans.

A national perspective and value orientation was achieved through Agency promotion policies and intense bureaucratic socialization (Kaufman 1960; Robinson 1975; Twight 1983). Technical timber management plans were written within the Forest Service, but Richard Behan (1978, p. 314) points out that prior to World War II plans "were largely academic. They were plans for the management of timber resources that nobody wanted, as long as the private, commercial, and industrial forests of the country continued to supply sufficient old-growth timber at a lower cost. The federal land harvests never approached a growth constraint called for by the plans because they were scarcely needed at all." Until altered by the events following World War II, especially the increased timber harvesting in response to the pent-up demand for housing, planning could be characterized as an attempt at coordination between various uses, within a hazily understood doctrine of multiple use and sustained yield (Behan 1967, 1981).

It could have been little more, given the inadequacy of data beyond that known professionally by those working on the ground. The magnitude of the timber survey and inventory process, which had been authorized by the McSweeney-McNary Act in 1928, was immense. Ivan Doig (1976) points out that on the eve of World War II only 45 percent of the forest area in the continental United States had been roughly and crudely covered, and only about half of the gathered data analyzed. Subsequent studies, such as that by Wikstrom and Hutchison (1971) that questioned the basic land classification scheme used for inventory and timber planning purposes, showed that estimates of what was available were often inaccurate and generally ignored consideration of such factors as accessibility, probability of successful regeneration, and soil stability.

Richard McArdle, former Chief of the Forest Service, tells us that planning started in earnest when some quasi-military missions were assigned to the Forest Service in World War II. From the missions evolved the development of timber plans, transportation plans, and myriad separate and generally unrelated planning efforts at the National Forest and Regional level (McArdle 1973).

In the postwar period between 1945 and 1960 the major timber management questions seemed relatively settled. They dealt with management of the transition between existing forests and fully regulated forests. For example: the length of the conversion period, optimal rotation length, and associated practices. We can obtain a clearer picture of the rudimentary state of planning by looking at the concept as it was applied to development of timber management plans.

Ira J. Mason, Chief of the Division of Timber Management in the Forest Service, put it bluntly (Gross 1950, p. i):

> The Forest Service policy is to apply sustained-yield management to the national forests, working circle by working circle. . . . The forester's ideal is the normal forest where age-class distribution is such that perpetual cuts can be made annually of the same amount, equal to the annual growth. If such perfection should be achieved, the management plan objectives would be merely to maintain it. The ultimate objective of sustained-yield management is the development of a fully stocked normal forest. . . . Since there are no national forest working circles with stocking and age-class distributions closely resembling a normal forest, the intermediate objectives for the period for which the management plan is prepared [must consider problems associated with timber dependent communities, but otherwise should aim] for more rapid progress towards normal age-class distribution [as soon as practicable].

L. S. Gross wrote the handbook that served to combine understanding and knowledge of local conditions and existing policies into a working tool called the timber management plan. Brevity, without loss of important detail, was an essential goal of his effort. Again, the questions to be answered in a management plan are clear (Gross 1950, pp. 1,4):

> Each management plan must be realistic [and] should evaluate present conditions and trends in terms of future developments, but it should prescribe the most intensive silvicultural practices which can be given practicable application. . . . Periodic revisions often will stipulate more intensive forest practices than seemed desirable when the original plan was prepared. A timber management plan is essentially a plan of operation covering a period of years. The usual plan should outline in a general way the policies and objectives for the first rotation, or an equivalent period. Details of the action plan should cover the first cutting cycle or the first budget period. No one can foresee the future sufficiently well to make detailed plans which can be followed throughout the next 100 years or more. . . .

And to make matters worse, stated Gross (1950, p. 19), although "numerous formulas have been developed [to aid area and volume regulation]. . . many are highly theoretical [and] most imply the availability to the management planner of a wealth of data on inventory, age classes, growth rates, etc." The formulas, nevertheless, were widely used to prepare timber activity and harvest schedules, which were statements of when, where, how, and how much timber should be cut and grown to reach owner objectives. As such, timber activity schedules formed the heart of forest management.

Planning timber activity schedules was and is a major focus of both the Forest Service and some private firms.

For much of this century, simple formulas sufficed in setting timber schedules. These formulas generally were divided into two kinds: area control and volume control. Regulation could be achieved by "allocating the cut" on the basis of (1) the area to be harvested each year, (2) the volume to be removed annually, or (3) a combination of area and volume.

With area control, the emphasis was on annually cutting an area equal to the area to be annually harvested in a proposed "fully regulated forest." This approach was familiar to foresters in Germany and other European countries, where centuries of intensive management had resulted in forests with relatively equal areas belonging to each age class. However, problems arose when the approach was applied on the relatively unmanaged American forests. Areas varied in the volume of harvestable timber. There was the possibility of rather large fluctuations in the volume removed each year even though a constant number of acres were treated. There was also the possibility that by judiciously scheduling the compartments to be cut, it would not be necessary to cut exactly equal areas each year.

In practice, the usual result was variation in area scheduled for cutting from year to year in the interest of more regular volume yields. Of course, regularizing the volume was desired to "sustain" timber-dependent communities. But rising and falling prices for the output of mills made the demand for such regular volumes somewhat questionable. As Gross (1950, p. 18) put it:

> It may be necessary to make some silvicultural sacrifices to bridge otherwise lean years. In developing the allowable annual cut the management planner may find it desirable to permit limited overcutting in two ways: (1) When markets are good for less desirable species or products, they may be cut more heavily; and (2) in periods of poor markets, better species and more valuable products may be overcut, if necessary to sustain the community. Skillful manipulation is necessary, however, to insure that the actual cut is substantially in balance with calculated cut, preferably by budget periods.

With volume control, calculation procedures focused on the volume to harvest annually. Under European influence and the leadership of Gifford Pinchot, volume control was used to ensure that the annual allowable cut did not exceed annual growth. By the 1920's, however, it was apparent that this made little sense in the American context, particularly in the Pacific Northwest, where slow-growing old-growth forests predominated. If the "growth equal cut" formulas were continued, the old-growth forests would dominate the calculation and extend the length of time required to convert the forests to full production potential. For this and other reasons, planners in the 1920's sought a more flexible formula (Wilkinson and Anderson 1985). The most popular one, which appeared in 1922 and continued in use well into the 1950's, was Hanzlik's formula:

$$\text{Annual cut} = \frac{V_m}{R} + I$$

where

R = rotation length for young-growth stands

V_m = volume of merchantable (old-growth) timber

I = forest growth (increment in immature stands).

The Hanzlik method was particularly designed to regulate the cut and to permit the rate of harvest to exceed growth where virgin stands predominated. The problem is to cut approximately equal volumes each year, but to spread the old-growth volume over a sufficient number of years so that second-growth stands will be ready for cutting by the time the last of the old growth is cut. Hanzlik's formula provided one solution, but others addressed the problem differently. More importantly, other questions were being asked then as now, such as best rotation length, best management practice, and alternative treatments.

Many modern questions remain essentially the same. Simple formulas stressing forest biology seemed sufficient for such a task, at least up to the time that people began to wonder about alternatives for management of future stands and to wonder about the economic efficiency and social responsibility of such timber regulation approaches. Raised today in a more complicated context, the old questions answerable by the old tools now require more sophisticated approaches.

Only with the coming of computer technology could the ramifications of considering such questions as the impact on future yields of precommercial thinning, commercial thinning, and fertilization be adequately handled. Without the computer it would have taken a lifetime to do the routine calculations required via the Hanzlik and other simple methods. But with the computer, opportunities presented themselves to blend area and volume control. In addition, modeling progressed to incorporate aspects of forest ecosystem management beyond the scope of early work in timber activity scheduling. With the advent of the computer, full-scale multiple-use planning would finally be possible on the National Forests.

But in 1950 much of this development was still to come. As Gross (1950) interpreted the situation, the Forest Service for the time being could at best experiment with the various models at hand with no commitment for any of them. The Forest Service continued to encourage efforts to evolve and use tools that would help in solving management problems. Gross (1950) provides examples from timber management plans as they existed in the late 1940's. Davis (1966) gave an exhaustive presentation of the simple classical formulas (for example, the Hanzlik formula) and area and volume control techniques that had up until that time sufficed in setting timber schedules. Subsequent developments are described in detail in Gaffney (1960), Alston (1974), Samuelson (1976), and Behan (1978).

The 1950's and 1960's Introduce New Challenges

Marion Clawson (1983) described the era from 1900 to 1950 as one that emphasized protection and preservation of forest resources. In practice, it was a process of

custodial management. (See Dana 1956; Clawson and Held 1957; Shands and Healy 1977; Dana and Fairfax 1980.) The 1950's and 1960's, however, proved pivotal in the evolution of both national and individual forest planning practices. The 1950's, for example, have been described by Clawson (1983) as the decade of intensive management, while the 1960's and 1970's ushered in an era of "consultation and confrontation."

Following World War II the recovery in housing and construction was accompanied by a remarkable increase in the demand for timber. Rising stumpage prices stimulated increased western and southern timber harvests. The private forestry sector, particularly in the South, recognized that the time had finally arrived when investments in reforestation made financial sense. Given the shorter rotations in the South and the emergence of intensive forest practices on private industrial lands, the demand on public timber was increasing but not drastically so (Duerr and others 1979).

The situation was different in the West. In spite of Forest Service efforts to encourage sustained yield forestry, western forests seemed to be depleting at a rapid rate. This was particularly the case in the old-growth forests. Douglas-fir stumpage prices, for example, began a sustained rise following World War II, rising nearly 15 percent per year from 1945 to 1955 (USDA-FS 1957; Duerr 1960).

In the late 1950's timber harvest levels on commercial forest land (public and private together) seemed to be reaching the maximum sustainable yield, as established through analyses that emphasized single-rotation planning. Analysis of the timber supply situation, particularly in Washington and Oregon, became a major effort in the 1960's and 1970's.

Public foresters have long had a timber famine mentality (Bennett 1968), a pessimistic outlook revealed in early supply-demand studies by the Forest Service. These early studies were hampered by a shortage of data and had a tendency to lay blame for the Nation's forestry problems on private ownership and private silvicultural practices. Improved official timber trend studies in the 1940's and 1950's forecasted increased demand. But by this time pessimism had been replaced by an optimistic feeling that intensified forestry could overcome supply and demand problems well into the future.

Following the Copeland Report came more nationwide forestry problem analyses at increasingly frequent intervals. The Forest Service published reports in 1935 (*Forest Land Resources, Requirements, Problems, and Policy*), 1940 (*Forest Resource Conservation*), a reappraisal in 1948 (*Forests and National Prosperity*), and the Timber Resource Review (TRR) in 1958 (*Timber Resources for America's Future*). William A. Duerr (1960), who was to become a principal actor in the analysis of the timber situation, noted that the reappraisal report lacked the cautious pessimism of depression time, but contained a new, adventurous optimism tuned to visions of postwar prosperity and abundance. He said the estimated high level of timber requirements suggested that forest depletion was the basic problem, particularly on the small, nonindustrial, privately owned commercial forest land. In the Timber Resource Review the spirit of the reappraisal was continued, but with a call for intensity of forest practices by all ownerships that would startle many people. "Can do management" would replace the concept of timber reservation, and sales from public lands would be allowed to increase to meet the industrial demand.

Relatively candid assessments of the problems created by this new-found optimism and faced by the Forest Service in the early 1960's are found in *Management Practices on the Bitterroot National Forest* (USDA-FS 1970) and *Forest Management in Wyoming* (USDA-FS 1971). The Wyoming study (p. 8) put the problem in a nutshell:

> A primary target of protest, the apparent overharvest of timber, was partly a response to Federal law and USDA regulations that the Forest Service harvest timber to satisfy an obvious public need. It is apparent now that the estimates of allowable cut were partly based on over-optimistic assumptions as to the amount of growth on forested land that was suitable, available, and economically feasible to harvest. Since much of the forested land in certain parts of Wyoming is unloggable under present technology, the cut was concentrated in the area that could be logged.

The inability of extant models to offer planners both spatial and temporal analyses had resulted in a massive public outcry at the management results. Times had changed, and forests were being viewed as important for uses other than solely as a source of wood fiber. People began to question whether or not current timber management practices were consistent with sustaining and increasing the other uses of the forest.

Therefore, the pressure for increased harvests was accompanied by increasing demands for other outputs and resources of the National Forests. Edward C. Crafts (1970, pp. 14-15) argues that these pressures had:

> ...induced the Forest Service to consider seriously legislation that finally evolved as the Multiple Use-Sustained Yield Act. These included: (1) the drives by various organizations for single use or priority for their special use; (2) increasing conflict between national forest uses and users; (3) growing pressures to overcut national forest timber; (4) unclear legislative directives for recreation and wildlife use, and (5) internal coordination problems within the Service. The timber pressures lead [sic] to the Timber Resource Review (TRR) and grazing pressures to the 1953 Annual Report of the Chief on "Grazing in the National Forests."

Crafts states that the threat to wood sawtimber was obvious and was taken seriously by the Forest Service even when others did not. "It is significant," states Crafts (p. 15) "that the final [Timber Resource Review, 8 years in progress] was completed in 1958, the same year the first Multiple Use - Sustained Yield bill was introduced in the Congress." The combined pressure led, ultimately, to a series of studies on the "timber supply problem." Initially, the focus was on the Douglas-fir region of the Pacific Northwest.

Timber Trends in the Douglas-fir Region

Timber Trends for Western Oregon and Western Washington (USDA-FS 1963), also known as the "Duerr Report," seemed to indicate that then-current practices and harvest levels on private forests could not continue into the future without an eventual decline in available timber, unless supplemented extensively by sales from the National Forests. Duerr's additional analysis (Congressional Record 1966) suggested that changes in public harvest practices could more than make up the projected decline. Johnson (1986, p. 2) states that the analysis "established that timber harvest levels could be set for reasons other than that they satisfied a formula."

However, calculations of sustainable public harvests based on available timber supply models were not sophisticated enough to answer all of the questions surrounding existing timber management and multiple-use policy. Early formula models and area-volume check methods provided solutions for specified conditions but did not assess alternative resource allocations to satisfy a specified objective. Formula models could not recognize differences in stand structure; area-volume check methods could. Neither were capable of handling the multitude of silvicultural treatments available. In spite of their deficiencies, the methods were widely used well into the 1960's (Neff 1973).

As pointed out earlier, classical timber management formulas, such as Hanzlik's, had been designed to determine the harvest rate to bring an old-growth surplus forest into regulation. Considerable improvement in terms of building economic considerations into such calculations was achieved by financial maturity models, which took account of the costs of capital rather than simply calculating biological culmination of mean annual increment. Although such financial models had been discussed in the literature since the nineteenth century, they had not much influenced public policy (such as decisions about investment levels or rotation lengths). But financial maturity models were not scheduling tools. The only scheduling models available up to the 1960's were simple formulas and brain/pencil-operated simulations augmented by map overlays and experience. These approaches and analytical methods proved inadequate for the tasks facing the Forest Service. Nevertheless, timber activity scheduling models developed by the Forest Service in the 1960's and early 1970's continued to be oriented toward ensuring the sustainability of timber harvests, not evaluating the interaction of timber with other resources.

The *Douglas-fir Supply Study* (USDA-FS 1969) added a new twist to the calculation of sustainable harvests by using allowable cut calculation procedures that looked beyond one rotation and by examining several flow patterns for public and private timber harvest. The differences in flow patterns were made possible by the development of computerized models that were the groundbreaking predecessors of those discussed in the next section. ARea VOLume Check Method (ARVOL, Chappelle 1966) was a computerized simulation model that used the area-volume check method. ShOrt Run Allowable Cut (SORAC, Chappelle 1968) was a substantial improvement in that it was specifically designed to look beyond the current rotation toward how intensively managing the regenerated stands might affect current harvest levels. A high degree of complexity in using this approach is represented by Simulating Intensively Managed Allowable Cut (SIMAC). SIMAC was a simulation model that permitted the introduction of a wide range of management practices characteristic of intensive management. It was developed for use by the Bureau of Land Management as well as the Forest Service (Sassaman and others 1972). Also coming on line at this time was a new genre of linear programming models (such as Timber RAM and MUSYC, discussed in the next section) that not only addressed these issues but also opened up avenues of analysis in broader aspects of the evolutionary transition from functional to integrated land management planning.

Multiple Uses Meant Multiple Problems

In the absence of intensive practices, as forests changed from cutting old-growth acres to cutting young-growth acres, the harvest would inevitably and permanently decline. This came to be known as the "falldown." The findings of the Duerr Report, together with those of the *Douglas-fir Supply Study*, held out hope that the "falldown" could be avoided. This hope was based on a widely held feeling that future growth in regenerated stands was a principal determinant of the allowable cut in the current period. It was implicitly assumed that increasing future yields through such practices as precommercial thinning, commercial thinning, fertilization, and improved genetic stock would be translated into higher allowable cuts in the current period. This notion became known as the "allowable cut effect" (ACE) and proved to be a focal point for debate during the early 1970's. (See Schweitzer and others 1972, Teeguarden 1973, Klemperer 1975, Bell and others 1975, and Hyde 1980.) In the mid-1970's yet a different model was developed that would allow the intensity of timber management, by owner class, to be an explicit variable in the projections. This model was named Timber Resource Economic Estimation System (TREES). TREES was used as the primary model in three attempts to analyze the future timber availability in Oregon. (See Beuter and others 1976 and Oregon State Forestry Department 1980.) TREES was also used by the Pacific Northwest Regional Commission's Forest Policy Project in a study of the Pacific Northwest (Oregon, Washington, and Idaho) that looked at forest-related policies and alternatives. (See Johnson and Tedder 1983 for a discussion of TREES and other model types not covered in this paper.)

Despite the notion of an allowable cut effect, the real limits to increased timber supply existed elsewhere. Roger Fight and others (1978, 1979) found that multiple-use management constraints reflecting other demands on the forest resources (such as water quality, recreation, or wildlife habitat) were so severe as to vastly limit the opportunities for narrowly focusing managerial discretion on timber program optimization. As Johnson (1980, p. 5) suggests, subsequent research in the 1970's reflected a different era:

> The Roadless Area-Intensive Management Study [Fight and others 1979] examined this hypothesis [that the non-declining yield constraint was the principal limiting factor on current harvest levels]

by testing whether intensive management dollars could be substituted for roadless area acres in maintaining the allowable cut on seven national forests.... The findings of the study challenged traditional assumptions that long-term growth was the major constraint holding down harvest on land available for timber production. Instead, the researchers found that commitments to forest outputs other than wood fiber were the major constraint holding down timber harvest.... As the 70s concluded, it became increasingly clear that the effect of timber harvest on water quality, wildlife, and visual quality would provide the major control on national forest timber harvest levels.

These important policy concerns led to the desire to construct models that not only could look beyond the current rotation, but could also make different assumptions concerning harvest-growth relationships and expected future growth on regenerated stands. More detailed information on the location of resources and activities would be needed. We have identified two interrelated problems: (1) estimating the existing inventory and its potential growth characteristics, and (2) translating that information into allowable cuts. The Forest Service would have to be able to limit timber sale commitments to those that could be met without disrupting other forest objectives. The first problem means that gross overestimates of the allowable cut on a forest would have to be avoided. Spatial relations are typically a second problem that becomes important in ensuring that allowable cuts are feasible, marketable, and compatible with other uses of the forest. Forthcoming models such as FORPLAN would eventually address this dual problem, but adequate analysis of the spatial and multiple-resource problems would have to wait for further model development and improved computers.

A formidable problem was the shortage of personnel adequately trained in the use of computers. Regional staff would have to be used as itinerant consultants to the National Forest Supervisors' Offices. Virtually no one then conceived of the demands for computer facilities that would come from those offices involved in the move from functional to integrated land management planning.

National Level Analysis Models

Before the 1970's were over, the development of computer-based analysis models had proliferated. The Forest Service was faced with a plethora of models developed within the Agency, by university researchers, and by industry. The next section discusses three important forest-level analysis models. Numerous models were developed to handle national and regional level analysis (Field 1973; Bell 1975; USDA-FS 1976; Chappelle 1977; Convery 1977); space allows only a brief discussion of one of these.

Peter Ashton and others (1980) developed an interactive system of four models capable of synthesizing pertinent masses of information into measures of economic, environmental, and social impacts. The National Interregional Multi-Resource Use Model (NIMRUM) used linear programming to allocate national and regional demands for renewable resource uses on the land base. The model was developed in response to the 1974 Forest and Rangeland Renewable Resources Planning Act (RPA) assessment and program analysis needs. RPA was mainly concerned with national level planning, and its primary purpose was to better document the budgetary needs of the Forest Service and to enhance long-term appropriations (Wilkinson and Anderson 1985). NIMRUM was designed to minimize operational costs of alternative national programs (the objective function) while addressing environmental concerns, range production, sustained wood yield, and wilderness.

The first model under the NIMRUM system was developed by the Multiple-Resource Use Interaction group of the RPA staff in cooperation with the Range group and was called a National Interregional Multi-Resource Analytical System (NIMRAS) (Pickens 1980). Although conceptually capable of including analysis of virtually unlimited types of forest resource uses, in practice it was limited to timber harvest practices, domestic grazing and range practices, and wildlife practices. A second model was designed to evaluate regional employment and earnings triggered by alternative national programs. A third model, Futures Foregone, developed by David Freeman, kept count of future options lost in terms of the way it affected citizens groups, the rate of impact, and the length of impact. A fourth model, Social Conflict, also developed by David Freeman, attempted to quantify the amount and direction of conflict patterns resulting from any particular national strategy, program, or alternative (Alston and Freeman 1975). The system of four models was used in the preparation of portions of the 1980 RPA assessment and program analysis. Other users of the NIMRUM system included budget planners and strategists in the Washington Office. However, it was incapable of fulfilling the needs of planners at the National Forest level because (1) it was national in scope and provided little help for forest and regional level planning, and (2) the costs associated with its use were simply prohibitive.

Following publication of the draft RPA assessment and program in August 1975, a national symposium sponsored by the University of California, Berkeley, and the Forest Service was held at Pajaro Dunes, CA, in May 1976. Workshop reports, preparatory studies, and participant discussion focused on what had been learned in that first go-around (Pemberton 1977). The primary conclusion was that the level of aggregation required for national level analysis made it difficult to link, in a site-specific manner, the nationally and regionally determined target level of resource production for specific National Forests. Needed was a local bottom-up approach to data aggregation for the assessment and forest level development of alternative plans. The only feasible approach, if meaningful integrated interdisciplinary planning was to be obtained, would be to turn away from the Forest Service's "product oriented approach." The summary of the symposium proceedings stated that "if it has not already become so, the traditional multiple use approach will soon become obsolete when the multiplicity of new demands becomes apparent" (Pemberton 1977, p. 12). Some of the symposium participants suggested that not only data analysis and planning decisions be kept at the local or regional level but also policy and direction be more decentralized.

These and other concerns lay behind the enactment of the National Forest Management Act (NFMA) in 1976. NFMA, and the regulations promulgated to implement the act, were aimed precisely at improving the forest-level planning process. Wilkinson and Anderson (1985, pp. 76-90) summarize the essential points:

> Uneasiness over the respective roles of local and national planning began with the advent of land use planning in the 1960's. . . . Modern land use planning did not assume that timber production was an appropriate use of all available commercial forest land. . . . As a result, national forests began to classify more commercial land as unavailable for full timber production, to reduce their allowable cuts, and to schedule fewer timber sales. . . . [T]he timber industry began to complain about the loss [and to complain about] allowing local planning officials to sacrifice national lumber and housing priorities in order to placate local concerns. Partly in response to this criticism, the Forest Service instituted the more heirarchical unit planning system [discussed in next subsection] . . . . The basic local-national planning issue is whether Congress intended local forest plans to meet the resource output goals of the RPA program. . . . The "top-down" theory maintains that Congress did not intend to allow parochial priorities of local plans to frustrate achievement of national needs. The "bottom-up" theory. . . argues [for] decentralized control over local land use decisions. A third position [which represents] [t]he Forest Service's current position is essentially an uneasy compromise between the top-down and bottom-up theories. . . [and] call[s] for an "iterative" exchange of information from local plans and direction from national plans.

The inherent conflict led one critic to call for actual repeal of the RPA/NFMA legislation (Behan 1981). Nevertheless, the national NIMRUM system continued to be used for the 1980 RPA assessment and program. But analysts' interests had shifted to developing models that would be able to generate site-specific multiresource forest plans. For this reason, we now turn our attention to forest level planning and to the linear programming models specifically developed for that purpose.

Forest Level Analysis

The rising demands for timber after World War II resulted in emphasis on improving timber harvest scheduling models. But the Multiple-Use Sustained-Yield Act of 1960 shifted the emphasis to a balanced approach in the use and management of the many resources available from forest and rangelands (Alston 1972).

The first coherent effort to address the multiple-use aspect of public forests came in the form of "multiple-use" plans prepared by each of the National Forests (Schweitzer and Cortner 1984). Although these plans were intended to recognize and balance all forest uses, the absence of adequate data and experience in nontimber-related planning resulted in "multiple-use" plans that were still largely timber oriented. (Even in 1986, in the absence of final Forest Plans, functional timber management plans were still prepared and were still the basis of most day-to-day management activities.) However, the "multiple-use" plans developed during the 1960's did represent a meaningful step toward defining management activities for individual resources.

Rising concerns for all values of the forests may eventually overcome the emphasis on timber. If so, historians may point not to the Multiple-Use Sustained-Yield Act, but rather to the growing recognition of potential environmental consequences of Federal Agency activities and to the passage of the National Environmental Policy Act (NEPA) of 1969.

NEPA required all agencies of the Federal Government to prepare environmental impact statements that identify and evaluate the long-run impacts of projects on the environment. In response to NEPA, the Forest Service in 1973 changed its system of forest planning. In addition to meeting the process requirements spelled out in NEPA and court decisions, a major objective was to ensure greater consistency among national, regional, and local land-use priorities (Wilkinson and Anderson 1985). Each Region prepared Planning Area Guides, which provided general guidelines concerning broad resource capabilities and expectations to be followed by each National Forest in the Region. Each forest prepared plans for subareas of forests called "units." While multiple-use plans were still prepared for entire forests, unit plans were prepared for individual subcomponents of the forest, usually encompassing a large drainage or several watersheds.

Classifying the forest into land-use zones was a basic purpose of the unit plan. Zoning attempted to take into account the unique spatial characteristics of and resource interactions on the forest. Typical zones were general forest zone, watershed zone, streamside zone, recreation zone, critical wildlife habitat zone, and critical soil zone. Management practices were specified or prohibited in certain zones. For instance, buffer zones along streams required special timber harvest practices to limit damage to the watercourse. In scenic or recreation zones, special requirements on size and shape of clearcuts could be imposed to maintain esthetic values. Landscape architects were called on to establish appropriate visual patterns.

In the early 1970's too little was known about multiresource interactions to attempt much more. As stated in the 1975 RPA Assessment (USDA-FS 1977, p. 228):

> Some research on the joint production of several products from the same land areas has been conducted, the impact of timber harvest upon water yield being the best example. Some other resource interactions have also been studied such as the big game livestock interaction in the West. However, most of the multiresource interactions have received very little study. As the competition for the use of forest and range lands increases, information on these interactions will be increasingly vital and the best hope of attaining efficient use of the land and water resources.

Nevertheless, Schweitzer and Cortner (1984, p. 115) correctly argue that unit plans "were the first truly 'interdisciplinary' or 'integrated' plans on the national forests.... Detailed attention was paid to defining environmental consequences and the social and economic impacts on forest dependent communities of alternative courses of action."

The unit plans, like the multiple-use plans, continued to be supplemented by functional plans for individual resources, and overall decisions concerning forest resource management were based on subjective weightings of the results of the separate analyses. But because timber management plans continued to be the most sophisticated and well-documented in a quantitative sense, they tended to dominate the more qualitative plans for other resources, although this varied significantly from forest to forest. National level analysis was becoming an important part of the overall Forest Service planning effort, but in the early 1970's essentially all decisions for each forest were made locally. During this period the major influence of national level analysis showed up in the form of budget allocations to National Forests and Regions. This period was also marked by a substantial increase in the number of plans called into dispute by various publics, including litigation and an increasing role for the judiciary in settling disputes.

Among the more important of the computerized analysis systems used in forest level and unit planning (other than Timber RAM, which is discussed at length below) was the Resource Capability System (RCS) developed by the Watershed Systems Development Unit at Berkeley, CA (1972). RCS was designed to simulate the response of on-the-ground resource analysis units (land areas with similar soil types or other natural resource characteristics) to alternative management strategies. Resource analysis units thus grouped similar parts of the forest into "zones." The RCS resource analysis areas were often the basis for classifying land use zones for unit planning purposes.

Much like the models discussed in the next section (Timber RAM, MUSYC, and FORPLAN), the RCS model was a linear programming (LP) optimizing technique consisting of a matrix generator that assembled data into a structure suitable for LP analysis, and an output display or report writer. Once assembled by the matrix generator, data would be processed by a commercial LP code. The solution to the LP problem would be interpreted and displayed by the report writer. The LP code evaluated alternative natural resource output and use levels for each resource within management objectives, constraints, and land capability. As with any systems analysis approach, users would interact with the model, making minor adjustments and solving several slightly modified LP problems from each matrix generated by RCS. Because LP problems are abstractions from the realities of on-the-ground management, thoughtful user interaction is an indispensable part of the process.

Used for multiresource planning, RCS scheduled strategies over time, allocated acreage to specific management activities, and identified levels of resource output in response to the allocated acreage. RCS identified the maximum (or minimum) value of an objective function (for example, maximize timber or other resource production, maximize present net worth, minimize specified costs) subject to constraints. The developers of RCS represented the functional area of watershed within the Forest Service, and the model reflected their world view. Thus, RCS paid particular attention to simulating the water quality and water quantity effects of alternative activities (Johnson 1986). Timber was treated as just another output. RCS represented an alternative approach to the timber scheduling models that had been important to the Duerr Report and the Douglas-fir Supply Study and that had dominated much of the multiple-use and unit planning efforts. Within RCS were programs related to (1) onsite watershed analysis, (2) economics, (3) resource allocation and development planning analysis and display, (4) general support programs, (5) statistics and plotting, and (6) editing and general data handling (Hill and others 1974).

A subsequent version of RCS known as the Resource Allocation Analysis system (RAA) eliminated the response simulation models. RAA was used by both the Willamette and Beaverhead National Forests in the formulation of their plans. The Watershed Systems Development Unit at Berkeley, CA, was considered by many to be the effective intellectual center of National Forest Systems modeling in the early 1970's.

RCS might well have been developed into the model specified for use throughout the Forest Service if time had allowed correction of two fatal flaws. It would have to be able to recognize multiple classifications for the same area of land (that is, strata-based analysis areas discussed in the next section). It would also have to diffuse the perception that it was biased toward hydrological concerns. But competition between model developers and between functional staff groups in the Washington Office, the resulting confusion among forest planners, the continued dominance of timber in the ethos of the Agency, and the desire on the part of the Washington Office Land Management Planning staff to have one unified approach for public involvement, led to the decision to designate the FORest PLANning Model (FORPLAN) as the required primary analysis tool for National Forest planning (USDA Forest Service 1979). As Johnson (1986, p. 10) makes clear, however, "The emphasis of RAA on equal treatment of all activities and outputs and their portrayal as 'timestreams' of yields influenced the development of FORPLAN," particularly Version 2.

Summary: Evolution of Planning Led to Systems Approach

Gifford Pinchot's emphasis on wise use and planning as a means to ensure that resources would be used for the benefit of the Nation while at the same time preserving the productivity of the forest reserves has been a thread woven throughout this historical account. His desire for decentralized administration and planning that emphasized local concerns while being responsive to national needs has always been controversial but still guides the Forest Service today. What has changed is the perception of how best to accomplish that noble purpose.

Project planning dominated by independent and functional analyses for each of the separate resources proved unable to meet the needs of decision makers faced with increasing competition between and rising demands for the many resources and products of the forests. Timber and other commodity resource plans gave way in the 1960's to multiple-use plans, but timber plans and harvest scheduling dominated the process. Some sophisticated computer models for timber scheduling could look beyond the current rotation and anticipate the benefits of intensive forestry, but the models did not effectively deal with resource interaction. Various laws, including the Multiple-Use Sustained-Yield Act, NEPA, and NFMA, increasingly required a shift from single resource planning to **multi**disciplinary, and ultimately to **inter**disciplinary planning.

Each step in this evolutionary process required an analytical foundation to support advances in evaluation of all functions and alternative actions in the context of integrated and complex ecosystems. The pace of change is accelerating. As Schweitzer and Cortner (1984, p. 121) argue:

> It took approximately 55 years before planning for public forestry progressed beyond the limited timber plans to encompass planning for a broad array of forest goods and services. Since about 1960, however, far reaching changes have occurred at an accelerating pace. These include changes in the nation's fundamental perceptions of how the national forests should be managed and an increasing insistence that all plans of government be rational and available for inspection. The processes and analyses followed by the agency have changed greatly in response.

We have viewed the changing processes, and we now turn to that part of the story that concerns the analyses.

SECTION II: THE EVOLUTION OF LINEAR PROGRAMMING MODELS AS FOREST SERVICE ANALYSIS TOOLS

The evolution from the functional timber yield estimation-harvest maximization days of Timber RAM to integrated forest planning efforts using FORPLAN reflects the work of many people and spans more than a decade (Iverson 1982). Subsequent parts of this paper focus on the nature of the problem identified by the developers of the models and on the changing technical specification of the models as the analysts attempted to take into account real-world problems and new requirements of planning legislation and policies. For the reader's convenience, terms used throughout the rest of the publication are found in appendixes I and III.

Many of the analytical tools discussed in section I and all of the models discussed in the following pages are linear programming (LP) models. Persons lacking familiarity with LP often believe it capable of doing more than it can. Realistically, LP is a mathematical technique that allows decision makers to compare the ability of alternative management strategies (that is, schedules of specific management activities) to meet stated goals within available resource limitations. An understanding of model specification is important. If managerial decision making is to be modeled, the linkage between the variables internal to the model and the decisions made in the day-to-day management of the land must be explained. A correct specification of the problem requires that management decisions be traceable in terms of modeled decision variables.

For the models discussed here, a decision variable is associated with an activity column representing a prescription for land use on an identifiable area of land. The term "variable" derives from the flexibility under the strategy to manage either no acres or up to some stated number of acres. Once constructed, decision variables are evaluated according to specific criteria stated in terms of a constraint set and an objective function. The LP model selects decision variables that optimize the objective function within the bounds of the constraint set, the residual or unused decision variables being set to zero. Activity columns and constraint rows effectively delimit the range of production options considered. The objective function guides the LP model toward a solution that represents an "efficient" assignment of acreage to land use strategies. An efficient assignment in this limited context is one where the objective function achieves a maximum (or minimum, if desired) subject to fulfilling constraint requirements.

Computerized LP models have thus become popular not because the models make decisions, but because they can facilitate better decisions by evaluating several hundred thousand decision variables in a fraction of the time it would take to locate the best combination of decision variables by hand. The alternative solutions offered by the LP model become important pieces of information to be used in the human decision-making process. Often, the process of using such models, which force careful consideration of assumptions, data, and tradeoffs, is as important as the output of the models themselves.

We now turn our attention to three LP models: Timber RAM, MUSYC, and FORPLAN. Understanding the models and the events that led analysts to abandon Timber RAM and then MUSYC in favor of FORPLAN should help the reader comprehend FORPLAN as an analytical tool useful in developing forest ecosystem management plans.

Timber RAM

The Timber Resource Allocation Method (Timber RAM, Navon 1971) was developed by Daniel I. Navon and others at the Pacific Southwest Forest and Range Experiment Station following several years of experience with computer-oriented models developed in the mid-1960's (Amidon 1964, 1966; Broido and others 1965; Navon 1967; Navon and McConnen 1967; McConnen and others 1967). The model was designed to help formulate "plans which are efficient with respect to stumpage harvested, costs, or revenues, and which are consistent with specific management policies and available resources" (Navon 1971, p. 22). Navon (1971, p. 1) describes the model as follows:

> Given an inventory of forest resources and alternative ways of managing each type of stand, Timber RAM can be used to calculate a schedule which meets a specified objective, such as: maximize revenues, maximize stumpage volume

harvested, or minimize expenditures. Besides meeting the objective, the Timber RAM schedule can be required to meet constraints on the periodic level of revenues, and expenditures, and on the periodic volume of stumpage harvested. The levels at which revenues, expenditures, and stumpage are constrained can be varied from period to period. Finally the Timber RAM schedule can be required to meet constraints specifying what percentage of each type of stand will become accessible for cutting in successive periods.

Specifically, the model would predict the optimal sustained level of harvest, in a localized area such as a National Forest, given specified assumptions. Use of Timber RAM to answer questions relating to biological sustainability of harvest placed the model in company with ARVOL, SORAC, and SIMAC discussed in section I. Timber RAM, however, used a linear programming approach rather than a binary-search approach to harvest scheduling. Johnson and Tedder (1983) provide a thorough discussion of the two approaches.

Model Specification and Use—Timber RAM was used most frequently to address issues relating to biological sustainability of timber harvests, and to answer the question: What is the maximum sustainable harvest level for a forest? Model specifications included (1) an objective to maximize first period cut, (2) harvest-growth information for the stand classes represented, and (3) a harvest flow restriction. The forestwide decision was how much and where to cut. Decision variables were structured to respond to the question: How many acres should be cut from each stand class in each period? The user would delimit the range of periods (typically decades) over which the stand could be cut and define a variety of silvicultural treatments for a stand class, with some discretion as to when treatments would take place. It is easy to imagine the construction of many decision variables for each stand class.

In the analysis, forest land would be divided into a specified number of timber classes, say k, where k was typically a number between 15 and 75. A timber class was defined as a collection of acres from across the forest sharing similar silvicultural and economic attributes. Douglas-fir mature sawtimber on high-site-productivity land might comprise a timber class. The number of acres included in any timber class would, of course, vary by forest. Acreage would vary as well by the number of classes so defined. The basic land stratification, homogeneous but noncontiguous, is hereafter referred to as "strata-based." Figure 1 shows that the world view represented in the model is a mosaic of timber stands for forested areas, accompanied by voids in other areas.

A series of timber management prescriptions or strategies would be constructed, each prescription representing an alternative sequence of silvicultural treatments spanning many decades to the planning horizon. In Timber RAM, prescriptions[1] include treatments for both existing timber stands and the managed stands that would replace them in the future. Associated with each prescription are decision variables, which keep track of acreage assigned to particular timing choices for prescriptions in the solution

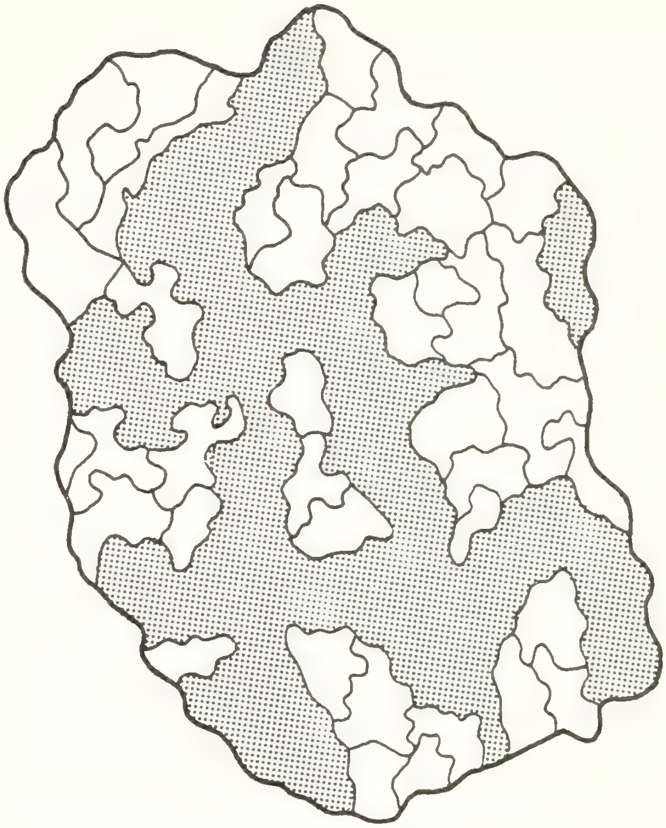

Figure 1—Mosaic of strata-based timber classes as delineated for Timber RAM analysis.

to an LP problem. As such, decision variables become the "choice" variables in the LP problem. Because the focus of the analysis was biological sustainability, the planning horizon was typically 120 to 300 years. The span of time represented in the model was divided into a number of periods, often decades.

Generally, constraints were added to the model in addition to those needed to track acreage within timber classes. These constraints controlled, for example, the rate of change in timber volume harvested from period to period. Such constraints could be used to simulate the effect of various forest policies.

Given user-defined timber classes and associated prescriptions, Timber RAM would develop a pattern of harvest that would at once satisfy specified constraints while optimizing the chosen objective. The sequence of acres to be cut in each period, coupled with the amount of

[1]The term "prescription" is introduced here to avoid confusion later on. Navon (1971) used the term "activity" for what we call a prescription, because a prescription was always represented as an activity column in a linear programming problem. Therefore, in our discussion of Timber RAM a prescription refers to a complete sequence of activities or treatments extending from the present to the planning horizon. A prescription is conceptually identified by a particular goal or "management emphasis" and by a particular "management intensity." The timing of treatments with associated outputs, costs, and benefits completes the specification. The term prescription, as shown in subsequent discussion, evolves along with the model development. In Timber RAM, prescriptions were related to timber production only.

timber removed from those acres, is referred to as a "harvest schedule." It is generated as a function not only of the single stand harvest-growth projections but also as a function of the timing of harvest cuts within and across stand classes to meet forestwide goals to the planning horizon. The yield projections would be exogenously developed based on assumptions about silvicultural treatments and their impacts on each stand class.

Prescriptions and associated decision variables were modeled at the stand class level with constraints generally reflecting overall forestwide goals and objectives. Even though stand classes were defined according to components such as working group or species mix, land class, and age class, the user could control harvest only by either individual timber class or forestwide. Harvest control by land classes, for example, was not allowed. As will be seen in subsequent discussion, this meant that managers would not be able to directly control harvest in critical subareas of the forest such as elk winter range or designated visual impact areas. Neither could they control harvest, for example, by species mix or harvest method.

"Constraints" in this era were often modeled as reductions in volume available for harvest. This type of constraint became particularly important after 1972 when a change in the Forest Service Manual required categorization of land into standard, special, and marginal components. Only standard lands reflected the full production levels contained in existing yield tables. By 1977, Forest Service planners had classified over a third of all commercial forest land as marginal or special (Wilkinson and Anderson 1985). In Timber RAM the reduced harvest volume implied by such considerations was usually modeled in one of two ways: reduction in harvest-growth volumes accompanying prescriptions or restriction of acres available for treatment in the first five periods. The first approach implies a constraint through yield reduction in the prescription columns. It was generally used for "special" and "marginal" lands. Yields for standard lands reflected full production levels. The second approach controlled access to a timber class through imposition of constraint rows called "accessibility constraints."

In developing harvest schedules, the analyst would typically run the LP model relatively free of constraints other than those needed to keep track of acreage in an accounting sense and to control harvest flow. The solution to this initial run would be subjected to scrutiny by specialists to determine on-the-ground feasibility. If deemed infeasible, additional constraints would be imposed and the model would be rerun until the specialists were satisfied that the selected prescriptions and decision variables represented on-the-ground management possibilities.

Navon (1971, p. 7) suggested that the above procedure could "be extended to include review of Timber RAM plans or revisions of Timber RAM problems by fire, recreation, range, and wildlife management planners." Ostensibly, functional timber management planning in the Forest Service would be sensitive to other resource demands.

Critical Evaluation—Timber RAM was billed as a tool for use in development of harvest schedules compatible with multiple-use management objectives. But could it live up to the billing? Timber RAM was, after all, a timber management planning model. Therefore, information from other resource specialists was interpreted and filtered by timber specialists resulting in an alleged bias that plagued Timber RAM and the models that evolved from it. Model developers, analysts, and planners who used the models were challenged by both internal and external critics to show that the models were not unduly biased toward timber. (The developers of RCS, as discussed in section I, were similarly accused of being biased toward hydrological and watershed concerns.)

But a potential timber bias was not the only issue. In studying wildlife management, Thompson and others (1973) identified modeling needs pertaining to the size, spacing, and distribution of clearcuts—considerations important in evaluating the intertemporal impacts of timber harvests. In addition, Walker (1971) looked at the economic implications of modeling situations where stumpage prices varied with harvest volume. Timber RAM could accommodate the latter problem (Hrubes and Navon 1976), but explicit demand curves were often absent or based on questionable assumptions. In practice, however, those and many other issues could not be easily represented in the model structures.

The use of intertemporal harvest flow constraints to simulate sustained yield in model specification was one approach to dealing with the charges of bias. Such controls represented flow constraints useful in forest regulation. But, in the eyes of other forest users, controls could also be used to restrict overcutting. In practice, harvest flow constraints were being used as surrogates for restrictions on harvest for economic, social, political, or environmental reasons. The policy of sustained timber yield could be, and almost invariably was, internalized in the form of a nondeclining yield (NDY) constraint. This constraint requires that the cut not fall from period to period within the planning horizon. Nondeclining yield became Forest Service policy in 1973 with the release of Emergency Directive 16 (USDA-FS 1973). However, the NDY constraint was often the sole mechanism, beyond the individual stand class harvest-growth projections, used to distribute the cuts through time.

Timber RAM was widely used to develop timber management plans for National Forests in the Western United States in the 1970's. The plans themselves were developed to address the questions of biological sustainability of the cut on a forestwide basis. The model served that need rather well. But the questions Timber RAM was designed to address were relatively unsophisticated, and as attention began to shift from growth maximizing formulas to site-specific environmental questions, more sophisticated model structures were required. The MUSYC model was developed as a first-stage response.

MUSYC

Multiple Use-Sustained Yield Calculation Technique (MUSYC, Johnson and Jones 1979) evolved from an attempt by K. Norman Johnson and others to improve the user orientation of Timber RAM. Desired constraints on timber harvest volume and silvicultural practices at or below the forest level dictated, it seemed, a complete overhaul of the Timber RAM computer code. The decision was made in the mid-1970's to revamp the system.

But a complete revamping did not occur. The end product maintained the older Timber RAM structure while adding a new one to it. MUSYC emerged with two mathematical structures designed for timber activity scheduling problems. Johnson and Scheurman (1977) outline these generic structures, labeling them "Model I" and "Model II." The key to understanding the distinction between them is found in the definition of decision variables.

In Model I, decision variables trace prescriptive managerial activities to the planning horizon, from the existing stand through, perhaps, several harvests on future regenerated stands. Johnson and Scheurman (1977) classify Timber RAM among models where decision variables are structured in a Model I format. In contrast, Model II is typified by a separation of decision variables. One set of decision variables traces actions on the existing stand. A separate set of decision variables traces actions on the land during the establishment and regeneration harvest of the subsequent stand. Each time a stand is reestablished, it is tracked with a new set of decision variables. Constraint rows link the two sets of decision variables and ensure that acres are properly tracked in an accounting sense.

The name MUSYC was acquired toward the end of developmental work on the system. Early on, it had been nicknamed "Model II" because the decision variables were so structured. Although it was conceptually appealing, Johnson and his coworkers soon found that some Model II formulations could create LP problems too large to solve efficiently. Johnson and Scheurman (1977) thought the Model II form produced more attractive LP problems with regard to computational efficiency than did the Model I formulation in Timber RAM. Forest Service administrators in Timber Management apparently also thought this because they chose Johnson rather than Navon to overhaul the Timber RAM computer code.

As Johnson (1977, p. 446) reveals, however, it quickly became apparent that computational efficiency is situational:

> Problem size for Model I is especially sensitive to minimum rotation age and problem size for Model II is especially sensitive to the number of acreage groupings at each age that must be maintained for future stands within each type-site. Which model is more computationally efficient in a given problem depends, among other things, on the users' preferences relative to these two key parameters.

This meant that instead of overhauling the Timber RAM computer code, Johnson would have to develop a completely new model and incorporate characteristics from both Model I and Model II. The Model I formulation was subsequently retrieved and the name changed to MUSYC. However, the "Multiple Use" in MUSYC was a misnomer because the model could handle multiple-use considerations, such as nontimber uses of the forest, only in the form of constraints on the timber harvest obtainable from various site classes. The prescriptions, in other words, were all timber oriented.

Enhanced Constraint Capability—In the tradition of Timber RAM, the MUSYC system was developed to address questions about general forest harvest and growth patterns. As suggested in Johnson's own account (1986, p. 7), timber planners using Timber RAM were demanding increased "ability to portray constraints that would reflect [the] emerging [social and environmental] restrictions on timber harvest" discussed earlier. They sought model enhancements that would help categorize information and develop constraints needed to control harvest with regard to area as well as volume. Johnson, in response, added the desired element of control to MUSYC, at least as it applied to timber class identifiers. In Timber RAM the timber class identifiers (working group, land class, and condition class) were used only to cluster information useful in specifying prescriptions. In both Timber RAM and MUSYC, an additional component, the "regeneration class" was used to allow for simulation of a variety of possible management regimes for future stand classes. Note that a timber stand would be identified by either a condition class (existing stands) or a regeneration class (future stands), but not both.

As discussed earlier, explicit constraint rows could not be developed by timber class component in Timber RAM. In the MUSYC system, however, users could aggregate information within and across these timber class components in developing constraints. Also, each possible treatment, such as a commercial thinning or a shelterwood regeneration harvest, could be named by treatment type. Users were allowed to develop constraints with regard to acres or volume treated forestwide by treatment type per period, and by groups of inventory categories formed by some combination of the identifiers. These constraints would allow control on, for example, the maximum number of acres clearcut in a given period for Douglas-fir mature sawtimber on sensitive soils. This was a substantial improvement on Timber RAM. In addition, reports summarized the results of the solution to an LP problem in terms of acres and volumes according to identifiers, treatment types, and time periods.

No doubt, improved constraint specification was helpful in projecting more realistic harvest schedules. In fact, the model gained acceptance in private forest land planning (Boise Cascade Corp. 1980) largely due to added flexibility in model definition and constraint capability.

Critical Evaluation—The problem with MUSYC relative to multiple-use planning was that it was just a more sophisticated timber management model. Enhanced subforest constraint capability was realized by further defining the strata-based timber classes seen in Timber RAM. This approach failed to give explicit recognition to the geographic areas important to specialists from wildlife, recreation, watershed, and so forth. (Some uses of RCS had focused on just such resource-specific analysis areas.) The problem with strata-based analysis areas versus geographically defined analysis areas is not just a timber versus nontimber problem. Strata-based analysis areas presented problems even when timber alone was being modeled. Consider one common conflict: strata-based analysis areas can provide greater precision in estimating timber yields, but geographically defined analysis areas can provide greater precision in estimating timber costs wherever road costs are important. The latter information was critical if sensible economic analysis was to be possible.

Analysis of location-specific issues such as transportation analysis could not be easily accomplished in MUSYC. In the early 1970's simulation models for transportation system planning were capable of dealing with recreation travel, one-lane road simulation, and network analysis. Weintraub and Navon (1976) attempted to integrate silvicultural and transportation activities. Such models, while significant improvements over older methods of analysis, were still inadequate for complex planning issues. Not until the end of the decade did Malcolm Kirby and others at the Forest Service Management Sciences Staff, Berkeley, CA, develop Integrated Resource Planning Model (IRPM) to deal with the spatial aspects of transportation plans (Kirby and others 1980).

Both the temporal and the spatial dimensions of the timber management problem are crucial to development of acceptable management plans. Timber RAM and MUSYC were designed to address the temporal dimensions of the problem, and IRPM was designed to address the spatial dimension. The challenge would be to bridge the gap.

Furthermore, as discussed in section I, by 1976 RPA and NFMA laws had changed the nature of Forest Service planning. A step in the direction of interdisciplinary planning had been taken by the adoption of unit planning, but the need for spatial and temporal integration across the whole forest could not be met by that approach. Thus, in 1976 development of the MUSYC system and its required documentation stalled. Documentation was completed in 1979 (Johnson and Jones 1979). But long before that Johnson had begun work on a model to address the issues of integrated planning.

The need was for more locational specificity than is provided by strata-based forestwide decision variables. This was available in RCS. However, the wording of NFMA regarding timber management actions suggested a need to retain the harvest-growth information packed into the decision variables of Timber RAM and MUSYC. These were absent in RCS. The dilemma is evident. To at once retain information on timber yields, yet address nontimber issues such as cover-forage relationship on elk calving grounds, presented a formidable challenge. In addition to detailed timber yield information, information on roads and openings created by timber harvests needed to be considered in a manner consistent with the desired cover-forage relationships. Prescriptions defined only in terms of timber classes would no longer suffice.

FORPLAN

FORPLAN was developed by K. Norman Johnson and others to bridge the gap between functional resource planning and integrated land-use planning (Kelly and others 1986; Kent and others 1985; Johnson 1986). Whereas Timber RAM and MUSYC only analyzed commercial timberland, FORPLAN could accommodate all lands and water in the forest. The basic structure existed in MUSYC or Timber RAM. However, the role of the decision variable would need to be enlarged. Whereas previous decision variables traced activities needed to produce timber through time, FORPLAN decision variables would trace multiple resource activities through time. These activities are packaged in prescriptions associated with the decision variables.

A prescription in FORPLAN represents an integrated set of activities, outputs, costs, and benefits. As it applies to FORPLAN, a prescription is broader than the timber activities in Timber RAM. The activities may be accomplished within one period (generally one decade) or may span many periods. Prescriptions, however, trace the consequences of the activities to the planning horizon.

The coming of NFMA meant that truly integrated multiple-use planning was no longer just an idea—the law mandated its immediate implementation. "Lead" National Forests had been identified in Forest Service Regions, representing a set of forests that, through trial and error, would set the much-needed precedents for planning. On December 3, 1979, the Forest Service (USDA-FS 1979) designated FORPLAN as "the required analysis tool" for forest planning. The stage was set and the players identified.

Unfortunately, the rules of the game, if identifiable, were not easily followed (Field 1984). If timber and range classes (henceforth termed "analysis areas") could be defined on the basis of homogeneity of site and vegetative characteristics, recreation and wildlife analysis areas could not. Production of either recreation or wildlife requires diversity of site and vegetative characteristics. Analyzing these relationships would require models with a high degree of spatial orientation. Typically, for instance, a wildlife biologist would choose a contiguous area such as an elk "home range" as the relevant analysis area. Generally, FORPLAN would need to reflect the world view of each specialist separately and allow for cases where two or more specialists would write prescriptions for joint resource outputs from the same tract of land. That is, prescriptions for managing the land would need to be written for the separate production of timber or wildlife and for the joint production of timber and wildlife. Linkage was maintained in FORPLAN by creating a new class of prescriptions called "aggregate emphases."

Aggregate Emphases—This concept, developed in FORPLAN, represented for the first time a separation of decision variables for land allocation from decision variables for activity scheduling. The Forest Service planning process focuses on "analysis areas," which, when defined by strata, are homogeneous but not necessarily contiguous parcels of land. An aggregate emphasis prescription in FORPLAN packages broad management direction (typically a specific land-use directive) over a composite of analysis areas in a user-defined zone (Crim and Johnson 1981; Johnson and Crim 1986). Selection of a specific aggregate emphasis delimits the set of prescription choices for the strata-based analysis areas covered by the aggregate emphasis zone. That is, an aggregate emphasis associates a single management emphasis or a user-defined set of emphases to the analysis areas defined within an identified zone. Whereas FORPLAN without aggregate emphases provides decision variable choices for treatment of individual analysis areas, the inclusion of aggregate emphases provides choices both in the broader allocation of land and in the narrower assignment of prescription treatments to the land. Effectively, the model structure is one of choice within choice. Individual prescription assignment is made under the umbrella of an aggregate emphasis.

Figures 2A and B highlight the separate world views captured by the model. Figure 2A depicts an aggregate emphasis prescription displaying a roading proposal. Figure 2B depicts a mosaic of analysis areas.

Chappelle and others (1976, p. 291) pinpoint the significance of the role of aggregate emphases in providing a solution to the problem plagueing Timber RAM:

> Non-timber uses of the forest are handled indirectly in Timber RAM and essentially form constraints on timber production. Insofar as they are effective at all, they merely limit land available for timber activities and limit the range of treatments that may be applied in timber production.... [T]empering Timber RAM solutions with adjustments for "multiple-use considerations"...does not necessarily provide an optimal solution appropriate for forestry planning. [What is required is that] all goods and services of the forest [be] quantified within the objective function.

Chappelle and others, along with Navon and Lundeen (1974), felt that the problem could be eliminated if Timber RAM could be linked with another model, such as RCS, capable of allocating the total resource pool to a complete range of alternative forestry products. Aggregate emphases accomplished just this linkage in FORPLAN, at least in concept.

In FORPLAN, output yield and economic information may be associated with the aggregate emphasis directly or can be associated with prescriptions as before. For example, assume that an aggregate emphasis defined the roading of an important anadromous fish drainage, with the roading system designed primarily to access the available timber. The cost of the roading system is likely a shared cost for all the analysis areas within the aggregate emphasis zone. Either the road is built or it is not.[2] The cost is, therefore, associated with the aggregate emphasis prescription directly rather than trying to associate it with accompanying prescriptions for strata-based analysis areas separately. Similarly, output yields for recreation, sediment delivered to the fishery, and so forth, that accrue primarily due to the implementation of this aggregate emphasis, would also be assigned directly. Output yields such as timber harvest volume would be packaged in the individual prescriptions as before.

To fully comprehend the aggregate emphases scheme, the yield production process must be dichotomized. Some yield information (also cost and benefit information) is predicted at the analysis area level in development of prescriptions. Other yield information (also cost and

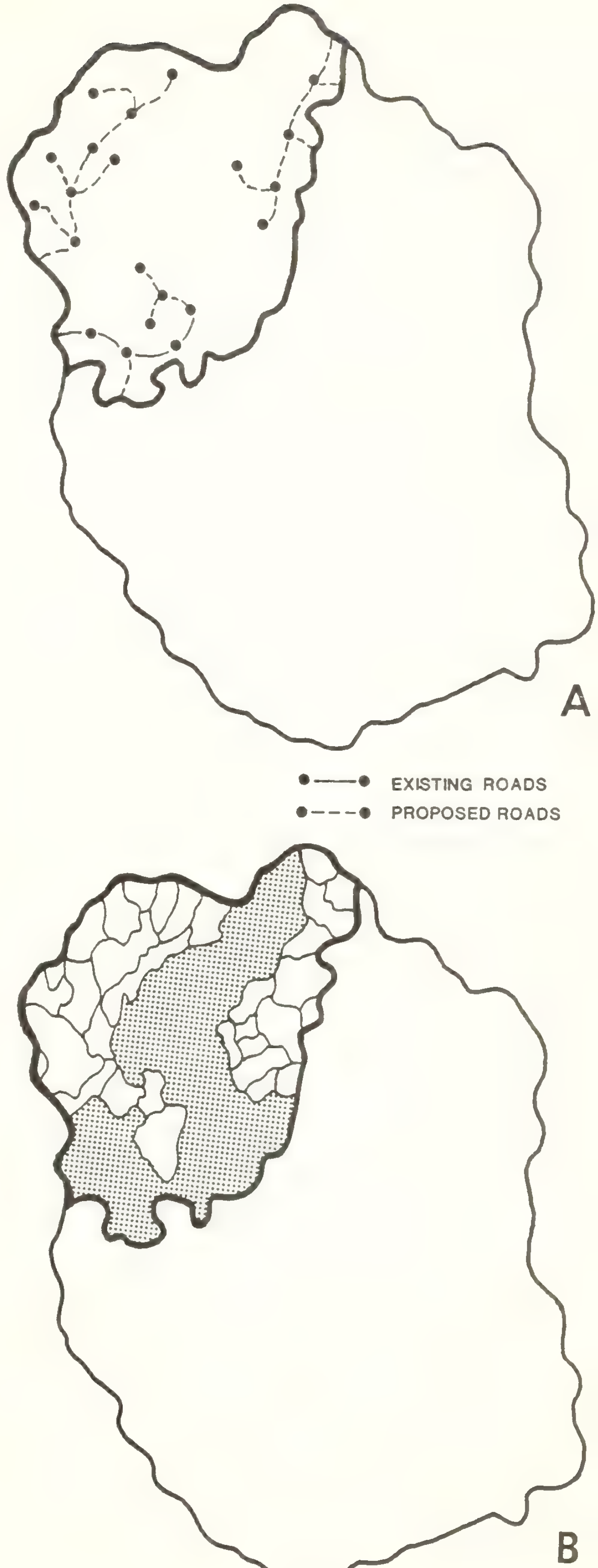

Figure 2 (A)—Aggregate emphasis prescription for a roading proposal (B)—Aggregate emphasis prescription for a mosaic of analysis areas.

[2]Note that when dealing with roads or other activities with a high degree of spatial content, the decision variable no longer represents a choice along a continuum. The choice is binary; either you make the choice or you do not. Therefore, linear programming cannot be used in its classical optimization mode, but rather it is often used to develop efficient prescription assignment for continuous variables given specified states for the binary variables. Johnson and Stuart (1986) give a detailed explanation of this problem and provide insight into several methods to resolve it.

benefit information) is predicted at the aggregate emphasis area level in development of activity schedules associated with it. A further refinement allows for timing options. That is, the user may structure several aggregate emphasis decision variables that are similar, yet differ with respect to period of implementation. For the roading example, this would expand the decision by adding a timing choice to the choice of whether or not to build.

The notion of activity scheduling for multiple resource production, and the notion of land allocation decisions being somewhat separate yet intertwined with the activity scheduling decisions, are significant milestones that set the stage for future development. In terms of analysis, they represent the major accomplishments derived during the initial development stages of FORPLAN.

Minor accomplishments included expansion of the ability to user-constrain output flows. With FORPLAN, users could constrain across subsets of lands, activities, and periods. Perhaps equally important was the movement away from timber supply estimates based solely on strata-based analysis that historically had resulted in relatively high estimates of the timber available for potential harvest. Each round of planning with FORPLAN results in better estimates of what would be available where and when. Reduction in the estimated potential harvest of timber is the case even when constraints for other resources are held constant.

Critical Evaluation—Although it was enhanced by the ability to track multiple resource outputs and consider land allocation decisions, FORPLAN was besieged with problems. Technical problems are covered in detail by Stuart and Kent (1982). Problems include (1) model size and (2) difficulty in generating spatially reasonable land allocations and activity schedules.

The first problem is one of model size. Stratifying a land base in the Timber RAM and MUSYC tradition typically resulted in 15 to 75 timber classes. FORPLAN stratifications for multiple-resource problems typically resulted in 250 to 800 analysis areas, with resource specialists begging for more. Further, use of the aggregate emphases notion often greatly expanded the size of the underlying LP. Each allocation decision variable is linked to a separate set of scheduling decision variables. Therefore, each newly considered allocation choice may have a multiplicative impact on model size. The twin factors of multiple-resource considerations and broad land allocation considerations treated independently would each have a significant impact on model size. Considered jointly, the potential impact on model size was staggering.

The second problem deals with the difficulty of generating spatially reasonable allocation/scheduling packages. Consider a currently unroaded 30,000-acre drainage with, say, only two aggregate emphasis prescriptions. The first leaves the area unroaded and does not consider any activity scheduling. The second prescription simulates development of roads for the area in the first period of the planning horizon. Further, this prescription is linked to prescriptions allowing for scheduling activities on the analysis areas within the drainage. Without the imposition of further constraints linking the timing of activities on adjacent and nonadjacent analysis areas in the aggregate emphasis zone, the model structure allows for many sequences of actions that might be undertaken in the drainage.

Ofttimes an assignment of prescriptions deemed efficient in an LP run will not be spatially reasonable in the eyes of at least one resource specialist. Determining cases where a model "run" simulates unreasonable timing choices and subsequently constraining away from these choices has proven to be time consuming and expensive. Such technical problems were troublesome but not insurmountable when the model was put into the hands of sophisticated and imaginative users. One ought not discount the creativity of forest analysts. Indeed, FORPLAN and its predecessors proved in the long run to be much more flexible than might otherwise be suggested by our treatment. The users proved to be adept, for example, at squeezing enhanced geographical specificity and spatial realism out of otherwise restrictive model structures.

The major problem with FORPLAN was not a technical one. Rather, it was a problem of perceived bias—a problem inherited from predecessor models. FORPLAN, itself a sophisticated timber scheduling model, proved cumbersome at best, and inappropriate at worst, to some integrated forest planning needs. Johnson and others (1986, p. 2) provide insight into two forms of criticism:

> [First], that FORPLAN was inherently incapable of modeling forest planning because it was a barely camouflaged enhancement of a functional model representing the views of Timber Management; and [second], that the specific capability of the model was inadequate to address forest planning problems. Many people saw a causal relationship between the two criticisms: that being a functional model (FORPLAN) would inevitably prove to be inadequate for the multifunctional, integrated planning required under the National Forest Management Act.

This criticism did not fall on deaf ears. Once again events would intervene, model development focus would shift, and a new model would emerge.

FORPLAN Version 2

In 1981 the Regional Forester in the Southwestern Region of the National Forest System (New Mexico and Arizona) received permission to use ADVENT (Kirby and others 1978) for National Forest planning. Because the focus of ADVENT was multiyear budgeting and program planning, and because it was not linked to a particular functional area, it was deemed acceptable to the planners in that Region.

Many people had long been uneasy about FORPLAN. Among them was Bill Russell, then Assistant Director of Land Management Planning and head of the Systems Application Group in Fort Collins, CO. He came from a range management background, making his approach to land management planning less likely to be served by the apparent timber bias in FORPLAN. But the support base for FORPLAN was not easily eroded. More than one debate took place in the Agency about which model would be appropriate. However, in the end Johnson became convinced that Russell, his supporters in the Southwestern Region,

and the less outspoken opponents to the continued use of FORPLAN were right after all. "As much as [Johnson] and his colleagues had tried to broaden the timber management planning perspective of FORPLAN, its terminology and orientation would always be foreign to many planning and resource specialists" (Johnson and others 1986, p. 3).

Johnson came to realize that FORPLAN's primary usefulness was for the heavily timbered forests in the Pacific Northwest and the Southeast. It had limited appeal to planners on other forests. As Johnson later put it:

> FORPLAN was bound to fail (as a universally applicable model) because it simply was incapable of answering the questions that some planners deemed most important. These planners (and the Forest Supervisors they worked for) were less interested in long term scheduling models than they were in being able to provide meaningful answers to their clientele relative to what would happen and where it would occur as a result of the Forest Plan in the next 10 years (personal communication 1985).

Under Russell's guidance, Johnson constructed a model dramatically different from FORPLAN (hereafter referred to as FORPLAN Version 1). Rather than exploiting yields from tables assumed to be widely applicable and associated with prescriptions for strata-based analysis areas, the user could define activities and resource products uniquely associated with the area in question. That is, the user would package into an activity column all the activities and outputs associated with an entire set of management prescriptions (including timing choices) for, say, a watershed or other user-defined zone to be managed holistically with a specific goal in mind. The new model was originally called Direct Entry (DE) FORPLAN, precisely because of the uniqueness of the data associated with each decision variable specified (Johnson and others 1982). Eventually the title DE-FORPLAN was abandoned and the model was, and is, called FORPLAN Version 2 (Gilbert and others 1985; Johnson and Stuart 1986; Johnson and others 1986).

At first, and from an accounting standpoint, the model presented to satisfy the desires of the Southwestern Region personnel was surprisingly similar to ADVENT. However, FORPLAN Version 2 did not resemble ADVENT for long because its capabilities were soon expanded. Johnson and his coworkers, especially Tom Stuart and Sarah Crim, worked diligently to create a new model that could overcome the criticisms leveled at FORPLAN Version 1, but without the need to jettison any of its capabilities. As Johnson and others (1986, p. 3) put it:

> In this [new] construction, a number of principles were followed: 1) the model would be compatible with the Forest Service Accounting System, 2) the different kinds of land organization—especially the strata-based and area-based approaches—would be equally possible, 3) the different kinds of data entry, especially unique data and shared data approaches, would be equally possible, 4) the data input conventions would be organized to avoid the need for the user to repeat data, 5) the ingredients of each management choice would be visible to the user, 6) the model structure would not favor any particular functional branch, 7) no particular problem formulation would be required, but rather the model would adapt to the user's perspective.

From an analysis perspective the real milestone embodied in FORPLAN Version 2 went beyond even the initial ideas that guided its developers. The key attraction to the analyst would prove to be the flexibility in specifying activity columns, decision variables, and constraints. In previous modeling efforts, a decision variable represented either a pure scheduling decision (for example, how many acres to assign to a particular prescription) or a pure allocation decision (for example, how many acres to assign to particular management emphasis). FORPLAN Version 2 allows the user to choose from along a continuum with traditional scheduling choices in the Timber RAM tradition at the one end and packaged land allocation - output scheduling choices in the ADVENT tradition at the other end.[3] That is, the user can package activities and outputs across space and time according to the dictates of the analysis at hand.

For example, if an inquiry into the biological sustainability of harvest were desired, the user could create a model structure similar to Timber RAM. Alternatively, if the inquiry was whether or not to enter into a previously unroaded drainage for timber harvest, the user might adopt an entirely different strategy and develop a simple exposition of, say, three scenarios. The first might involve no action and simply project outputs and effects through time. The second scenario might consider a roading activity, with outputs and effects, assuming helicopter logging. The third scenario might consider a different roading scheme derived from a cable logging system. Conceptually, three activity columns would have been developed. The activity columns formed could be called coordinated allocation schedules or simply "coordinated schedules."

Coordinated Schedules—A coordinated schedule defines the sequence of activities to take place on a user-defined area or zone to the planning horizon. That is, a sequence of activities, their costs, benefits, and environmental effects for, say, a 30,000-acre drainage in each period of the planning horizon would be totally user defined. Each package of activities (or activity column) would be associated with a separate decision variable. Alternative packages compete to see which one could most efficiently meet areawide or forestwide objectives and constraints. Each package would be constructed by an interdisciplinary team in an attempt to ensure that it is spatially reasonable. Figure 3 portrays a coordinated schedule wherein several roads are proposed along with a series of clearcuts.

[3]ADVENT was designed to evaluate competing projects. That is, each modeled activity column represents a separate project. To depict land allocation - output scheduling choices in what we term the "ADVENT tradition" requires, first, that a land-use zone must be identified, and second, that a sequence of activities, outputs, costs, and benefits must be identified that defines a management strategy for the zone from the present to the planning horizon. The "ADVENT tradition" represents a penchant for choosing between predefined projects or programs defined holistically. Use of ADVENT for broad land allocation decisions was infrequent, however, relative to use of the system in project planning and program budgeting (Kirby 1978).

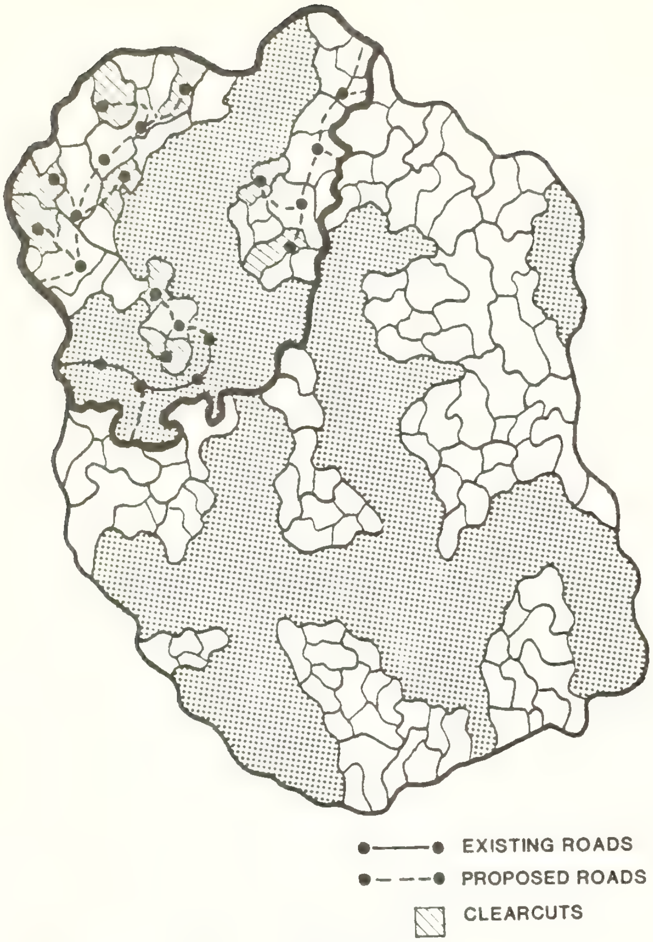

Figure 3—A coordinated schedule depicting several clearcuts and associated access roads.

Because a coordinated schedule spans all periods to the planning horizon, it is not easily represented in a figure. Therefore, a snapshot view at the end of period 2 is depicted in the figure.

Coordinated schedules can be developed in FORPLAN Version 2 in two ways: Unique yields can be input directly, or unique yields can be packaged from yield tables associated with prescriptions for strata-based analysis areas. In either case, the coordinated schedule is developed by an interdisciplinary team and is associated with a single decision variable in the model. (In recent documentation of FORPLAN Version 2 there is no reference to "coordinated schedules" [Johnson and others 1986; Johnson and Stuart 1986]. The terminology, however, still resides in the User's Guide [Gilbert and others 1985]. The terminology was not used in later documentation due to the possible negative connotation for output schedules developed in a different manner that might therefore be construed to be "uncoordinated." To this date no one has conceived of a thoughtful substitute for the term "coordinated schedule," and for this reason we use it here.)

Johnson (1982, pp. 9-10) emphasized the pros and cons in moving to coordinated schedules:

> Developing scheduling choices for areas instead of stands could, in theory, greatly assist in ensuring that environmentally feasible schedules be developed for the forest. Model size could significantly decline. A problem with one hundred areas each having the choice of 10 coordinated schedules would result in 1000 choices in total.
>
> The reduction in model size gives some clue as to a disadvantage in representing scheduling choices on an area basis. These choices are time-consuming to construct and require considerable imagination. Probably not all those that might be developed will be represented in the problem. Therefore, achievement of the objective specified for the problem may be reduced not only because of the constraints implied by the standards that must be met, but also because important choices were left out.

Flexibility in Problem Specification—FORPLAN Version 2 allows the user to analyze problems in several ways. Consider an "Allocation choice - traditional scheduling" formulation. Allocation choices (the Version 2 analogue of aggregate emphases) are developed for each zone represented in the problem. In addition, output scheduling prescriptions are developed for analysis areas defined according to strata represented in the problem. Decision variables for the two classes of prescriptions are mathematically linked. The linkage is a user option.

Analysis areas can be defined in a variety of ways in relationship to allocation zones. First, strata-based analysis areas may be specified within each allocation zone (fig. 4). In this case, activity and output schedules would be reported by zone as a part of the solution to a linear programming problem. The underlying model structure is identical to that developed for a similar aggregate emphases formulation in Version 1.

In a second case, strata-based analysis areas may be specified independently from allocation zones (fig. 5). The schedules reported by the model would not be directly traceable to the allocation zones. However, scrutiny of each allocation choice would determine whether or not (and when) acres would be available for activity scheduling. Once determined available, acres from one zone would be pooled with like acres from other zones for scheduling. The resultant activity and output schedules would be reported forestwide.

A third approach would allow definition of strata-based analysis areas according to user-specified combinations of allocation zones (fig. 6), with coincident schedules reported for the zone combinations.

In those cases where the user chooses to develop schedules at a level of aggregation higher than the allocation zone (cases 2 and 3 above), both problems and opportunities are encountered. Problems arise because users must prorate activity and output schedules back into the allocation zones. This process is cumbersome, but the solution to the LP problem offers some information useful in the proration. First, users know the allocation choice(s) selected for each zone. They also know whether or not (and when) analysis area acres are available for scheduling. It is left as a management decision, then, to reconcile the schedule into the zones. This brief introduction to the problem may hint at the opportunities.

Perhaps the most obvious result in cases 2 and 3 is that model size is reduced. There are also other opportunities.

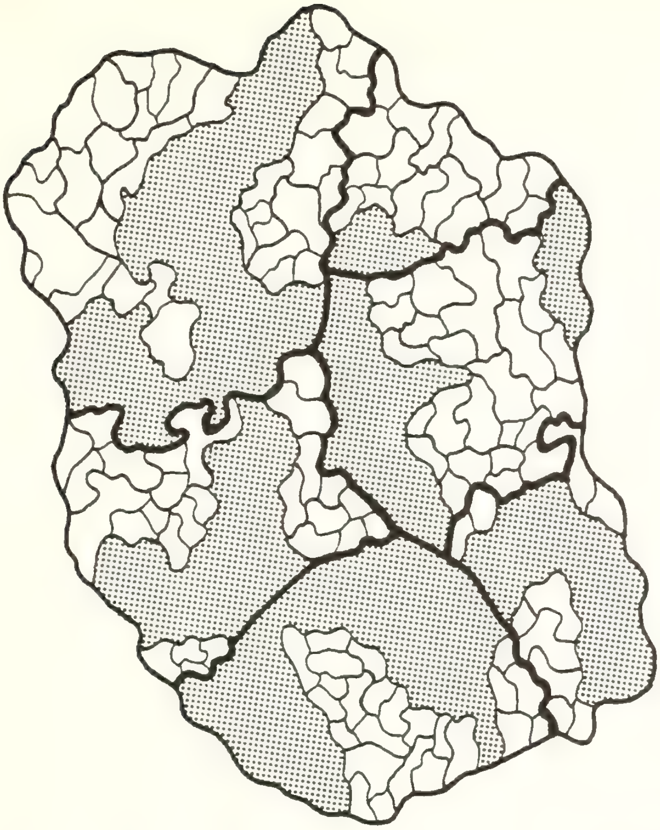

Figure 4—Strata-based analysis areas specified within each allocation zone.

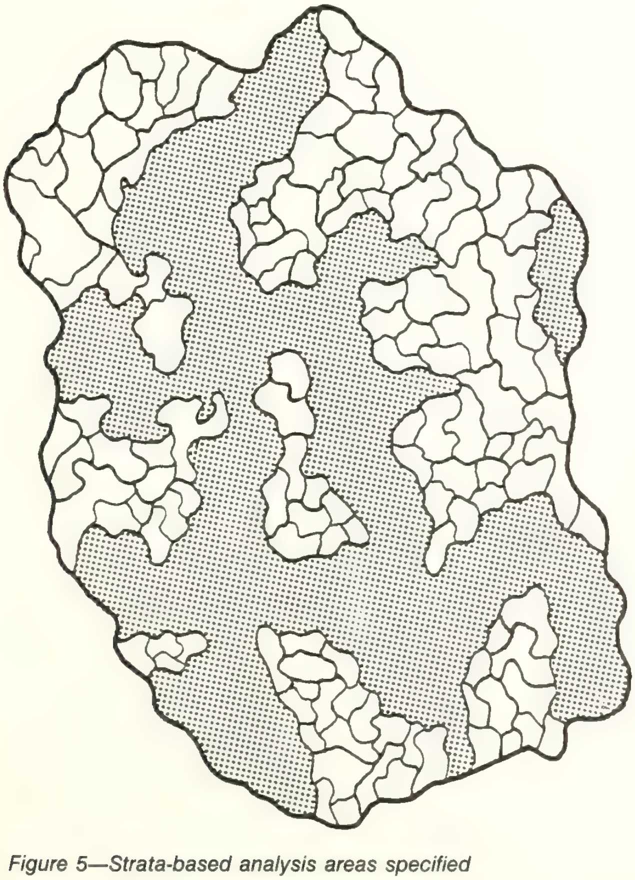

Figure 5—Strata-based analysis areas specified independent from allocation zones.

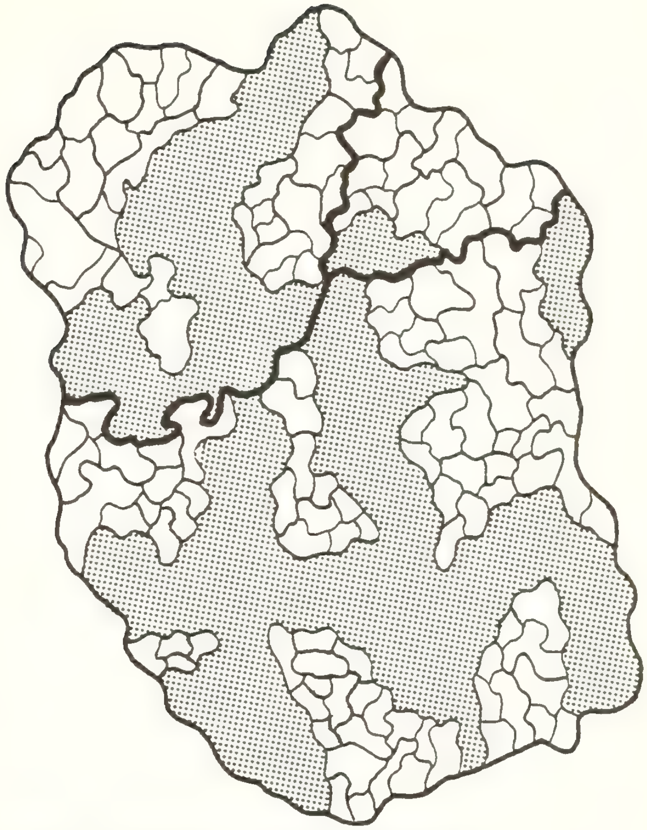

Figure 6—Strata-based analysis areas delineated according to user-specified combinations of allocation zones.

When using "traditional scheduling" formulations, site-specific information is not provided for prescriptions associated with strata-based analysis areas. As previously mentioned, the solution to an LP problem so structured would not be expected to be spatially correct when identified to the allocation zone level. Structuring the model such that activity and output schedules are not automatically developed for the allocation zones forces user interaction with the models in positioning the schedules on the ground. Similarly, the user interacts with the model in making allocation decisions. Human insight and intuition allow for a nonmechanical and reasoned apportionment of activity and output schedules within and across allocation zones.

The intertemporal aspects of the user options have not yet received as much attention as the spatial aspects. This class of options can be described from the "allocation choice - traditional scheduling" model framework. Consider a case where the user desires to specify the allocation for an area and dictate the scheduling for, say, the first two time periods. Beyond those first two periods, scheduling is not felt to be as critical, yet there is a need to monitor the flow of outputs and effects to the planning horizon. FORPLAN Version 2 allows the user to package information for an allocation choice and associated scheduling prescriptions for the first two periods into a single activity column for each zone. The process can be conceptualized as embedding the scheduling of activities and outputs for periods 1 and 2 into each allocation choice.

Traditional scheduling prescriptions for periods 1 and 2 would not be developed. However, prescriptions and decision variables representing scheduling choices for the remaining periods would be developed in exactly the same manner as in other "allocation choice - traditional scheduling" formulations.

In addition, FORPLAN Version 2 allows the user to define the point in time when acreage will be transferred from one prescription to another. This capability is a generalization of the Model II capability (Johnson and Stuart 1986). In Model II (Johnson and Scheurman 1977), a stand class (analysis area) transfers acreage between prescriptions at time of regeneration—that is, two or more sets of decision variables track analysis area acreage. The first set of decision variables tracks acreage through prescriptions defined for existing timber stands. The second set tracks acreage through prescriptions defined for the regenerated stands that replace existing stands once harvested, and so on.

FORPLAN Version 2 generalizes this concept and allows the user to define interrelated sets of decision variables for use in a variety of applications. For example, a user may wish to transfer acreage between decision variables as a function of the age of the overstory. In this fashion, analysis regarding the intertemporal dimension of catastrophic fire or insect infestations may be simulated.

In generalizing the available model structures, FORPLAN Version 2 allows users to specify differing parts of a problem with different model structures. This effectively allows the user to mix and match model structures situationally to better analyze problems.

Generalized Constraint Capability—In FORPLAN Version 2, constraint capability was generalized to include three broad categories of constraints: absolute constraints, flow constraints, and general relational constraints.

Absolute constraints are similar to the subforest constraints outlined for MUSYC. Except for the ability to aggregate activities or outputs or both, these constraints are largely similar to those in FORPLAN Version 1. Flow constraints generalize the idea behind "harvest flow" to any user-specified activity, output, or activity/output aggregate. General relational constraints allow the user to specify relationships between activities, outputs, or aggregates thereof. For example, a user might separately package costs and benefits deriving from the timber program. General relational constraints could be used to specify that the benefits exceed the costs in each period or that the benefits must cover a specified proportion of the costs.

Additional constraint capability allows the user the opportunity to link prescriptions and associated decision variables not easily connected through one of the general constraint categories. If we were to expand the previously mentioned roading example to include links in a road network that might or might not be developed contingent on prior construction of other links, we can readily visualize the need to consider other user-defined links between activity columns. FORPLAN Version 2 accommodates this use through a process referred to as "linked selection of coordinated allocation choices."

The capability to consider networking ties FORPLAN Version 2 with Integrated Resource Planning Model (IRPM) developed by Malcolm W. Kirby and others at the Forest Service Management Sciences Staff, Berkeley, CA (Kirby and others 1980). The method discussed here is a simple network structure. Sophisticated networks including "traffic flow" decision variables can be easily specified in FORPLAN Version 2. Johnson and Stuart (1986) point out that FORPLAN Version 2 can be used to analyze a variety of problems encountered in traditional "transportation planning" situations.

Critical Evaluation—Some may consider it premature to critically evaluate this version of FORPLAN. We share that concern. Nevertheless, some general remarks concerning linear programming as it is applied in forest ecosystem planning are appropriate. FORPLAN Version 2 represents the latest and a substantially different model in a series of models developed for this purpose.

Given the generic nature of FORPLAN Version 2, we argue that many criticisms leveled at earlier models have been overcome. Any computer model focuses all disciplines' attention on the same mechanism of analysis. FORPLAN Version 1 and its predecessors put timber at the focal point, with other forest resources, goals, and outputs on the periphery. FORPLAN Version 2, however, permits each discipline to redefine the point of focus—all forest resources have the opportunity to get into the middle. In this sense FORPLAN Version 2 is a positive force.

But criticism will not disappear. Rather, it will be focused on particular applications of the model. We are cautiously optimistic that such criticism will provide for better decisions on those projects and programs involved in such analysis.

Criticism regarding the use of mathematical programming techniques in forest management planning will no doubt continue. First, FORPLAN Version 2 is, after all, still a linear model and consequently doesn't handle nonlinear problems very well. Many thoughtful analysts see this as the major drawback of all models discussed in this section. Second, it is possible to build a model that is so complicated that even the analyst no longer understands why certain outcomes are identified as optimal. It is at least debatable whether such a model would add insight into the planning process. Users should also be cautioned that this model, like other models in the series, was not intended to provide answers to general equilibrium economic questions. Rather, the model is designed to simulate some of the consequences of alternative courses of action. Mathematical programming in general, and linear programming in particular, is most useful in understanding the nature of the problem, not in providing numbers representing the "answer" to a problem. Geoffrion (1976, p. 81) instructs that the true purpose of mathematical programming is

> . . . to help develop insights into system behavior which in turn can be used to guide the development of effective plans and decisions. Such insights are seldom evident from the output of an optimization run. One must know not only **what** the optimal

solution is for a given set of input data, but also **why**. The desired insights usually have more to do with the "why" than the "what."

In summary, then, we note that FORPLAN Version 2 is unique among the models we have discussed because it can handle a wider variety of problems that arise in forest management. It can simulate outcomes of forestwide allocation and scheduling problems, or it can be used to evaluate different projects. In the middle ground, the system can be used to evaluate groups of projects connected in time and space. It is also unique as a forest planning tool because it offers the opportunity to shift the focus of criticism away from functional concerns and toward the integrated planning process itself.

SECTION III: SUMMARY AND CONCLUSIONS

The evolution of Forest Service planning models has taken us a long way toward improving our ability to formulate problems in a manner that allows for sophisticated analysis and design. Millions of dollars and countless hours have gone into their development and implementation. This monograph has traced the development in forest planning thought, emphasizing the role played by harvest scheduling. Particular attention focused on the development of FORPLAN, which represents the work of many people scattered throughout the country. Just where have we arrived?

Randall O'Toole (1983) argues that with the emergence of FORPLAN Version 2 the Forest Service has reached the level of "total unintelligibility" and that people working with forests using the model will find that runs produced by it are far longer and more complicated than those of earlier models. From the perspective of citizens who desire to influence public forest policy, he could be right. The level of sophistication, and the concurrent ability to hide assumptions and manipulate data, have risen to the point that even trained users are not always aware of the ties that bind.

However, we reach a different conclusion. The authors share a desire to improve current land management planning. As economists, we are particularly concerned that whoever manages the land and plans its future uses be as aware as possible of the complex tradeoffs involved in multiple-purpose management. As we have reviewed the three-decade evolution of the planning models discussed herein, we conclude that in spite of the limitations inherent in any attempt to abstract from holistic reality through modeling the complex ecosystems that constitute our National Forests, the benefits may yet exceed the costs.

The shift in emphasis from a single-resource orientation to a multiple-resource orientation involved legislation on a national scale and Forest Service interdisciplinary team involvement on many units of the National Forest System. The models have evolved from Timber RAM to FORPLAN Version 1 and beyond in the form of the metamorphosed FORPLAN Version 2. Modeling emphasis has shifted.

Timber RAM and MUSYC were structured to answer questions relating to the physical-biological sustainability of timber harvest levels. FORPLAN Version 1, and more effectively, FORPLAN Version 2 attempt to respond to questions relating to financial consequences and environmental effects of any of a variety of actions undertaken in the course of managing a forest.

The application of FORPLAN to National Forest planning has surfaced problems relating to: (1) large linear programming models that proved to be costly (in some cases, prohibitively costly) to solve and (2) LP models that did not address well the spatial considerations of National Forest planning. These problems have been recognized, and their joint resolution is suggested in model structures available in FORPLAN Version 2. Clearly, the efforts through the past several years have not only helped better identify the problem but have also given insight into the modeling dilemma of problem size versus spatial reality. The key lies in problem identification and specification to simultaneously reflect land use and activity scheduling. The task of intelligently structuring the choices modeled is paramount.

FORPLAN Version 2, like its predecessors and other models being developed in the Forest Service to complement it, is merely a tool. As such it is capable of providing a reasonable approximation of the most efficient mix of management options consistent with the objective functions and constraints specified and the input data. If problems exist in the latter, they must be altered and improved.

Any tool that allows public land managers to ask "what if" questions has the potential of being useful. The more focused the questions, and the more accurate the input data, the more likely will answers be useful to thoughtful foresters. As William A. Atkinson (1986, p. 28) has argued: "Foresters must be able to interact with the model and interject opinions and 'common sense.' The thinking forester needs to be actively involved in management decisions; nature is far too complex to be reduced to pure numbers."

We believe that the evolution of models will continue and that we must move beyond what has been termed the "hacker" stage. "Realists" will recognize both the limitations and the prospects for use of complex models to aid decision making. The FORPLAN models are powerful analytical tools, but they must be used and interpreted with care.

REFERENCES

Alston, Richard M. FOREST: goals and decisionmaking in the Forest Service. Research Paper INT-128. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1972. 84 p.

Alston, Richard M. [Memorandum to Director, Intermountain Forest and Range Experiment Station, Ogden, UT]. 1974 December 18. [A critical technical report on a symposium held at University of Washington, 1974 November 23, on "The Economics of Sustained Yield Forestry"]. 23 p.

Alston, Richard M. The individual vs. the public interest: political ideology and national forest planning. Boulder, CO: Westview Press; 1983. 250 p.

Alston, Richard M.; Freeman, David M. The natural resources decisionmaker as political and economic man: toward a synthesis. Journal of Environmental Management. 3: 167-183; 1975.

Amidon, Elliot L. A computer-oriented system for assembling and displaying land management information. Research Paper PSW-17. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1964. 34 p.

Amidon, Elliot L. MAIDS2 - an alphanumeric map information assembly and display system for a large computer. Research Paper PSW-38. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1966. 12 p.

Ashton, Peter G.; Pickens, James B.; Ohlander, Coryell; Benninghoff, Bruce. Many resources, many uses: a system analysis approach to renewable resource development. Water Resources Bulletin. 16(4): 738-744; 1980.

Atkinson, William A. Zeroing in on zoned management. Journal of Forestry. 84(1): 27-28; 1986.

Baumol, William J. Economic theory and operations analysis. 4th ed. Englewood Cliffs, NJ: Prentice Hall; 1977. 695 p.

Behan, R. W. The succotash syndrome, or multiple use: a heartfelt approach to forest land management. Natural Resources Journal. 7: 473-484; 1967.

Behan, R. W. Political popularity and conceptual nonsense: the strange case of sustained yield forestry. Environmental Law. 8(2): 309-342; 1978.

Behan, R. W. RPA/NFMA - time to punt. Journal of Forestry. 79(12): 802-805; 1981.

Bell, Enoch; Fight, Roger; Randall, Robert. ACE: the two edged sword. Journal of Forestry. 73(10): 642-644; 1975.

Bell, Enoch F. Problems with goal programming on a National Forest planning unit. In: Proceedings of systems analysis and forest resource management workshop; Athens, GA. Bethesda, MD: Society of American Foresters; 1975: 119-126.

Bennett, John D. Economics and the folklore of forestry. Syracuse, NY: Syracuse University; 1968. Ph.D. dissertation. 246 p.

Beuter, John H.; Johnson, K. Norman; Scheurman, H. Lynn. Timber for Oregon's tomorrow: an analysis of reasonably possible outcomes. Research Bulletin 19. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory; 1976. 111 p.

Boise Cascade Corporation. Computer technology at work in the woods. Boise Cascade Quarterly Report. Boise, ID; 1980. 4 p. [Mimeo].

Broido, A.; O'Regan, W. G.; McConnen, R. J. Some operations research applications in the conservation of wildland resources. Management Sciences Ser. A 11(9): 802-814; 1965.

Cameron, Jenks. The development of governmental forest control in the United States. Baltimore, MD: Johns Hopkins Press; 1928. 471 p.

Chappelle, D. E.; Mang, M.; Miley, R. C. Evaluation of Timber RAM as a forest management planning model. Journal of Forestry. 74(5): 288-293; 1976.

Chappelle, Daniel E. A computer program for calculating allowable cut using the area-volume check method. Research Note PNW-44. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1966. 4 p.

Chappelle, Daniel E. A computer program for scheduling allowable cut using either area or volume regulation during sequential planning periods. Research Note PNW-93. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1968. 9 p.

Chappelle, Daniel E. Linear programming for forestry planning. In: Convery, F. J.; Ralston, C. W., eds. Forestry and long range planning. Durham, NC: Duke University, School of Forestry and Environmental Studies; 1977: 129-163.

Clawson, Marion. The federal lands revisited. Washington, DC: Resources for the Future; 1983. 302 p.

Clawson, Marion; Held, R. Burnell. The federal lands: their use and management. Baltimore, MD: Johns Hopkins Press for Resources for the Future; 1957. 501 p.

Congressional Record. Allowable timber cuts on federal land in Oregon—a tempest in a teapot. Unpublished excerpts from a preliminary review draft of a manuscript entitled "Timber trends in western Oregon and western Washington" dated August 1960, prepared by Division of Forest Economics, Pacific Northwest Forest and Range Experiment Station, Portland, OR. Testimony by Sen. Morse and others. January 17, 1966: 374-383.

Convery, Frank J. Land and multiple use. In: Clawson, M., ed. Research in forest economics and policy. Washington, DC: Resources for the Future; 1977: 249-326.

Crafts, Edward C. Saga of a law: Part I. American Forests. 76(6): 13-19, 52-54; 1970.

Crim, Sarah A.; Johnson, K. Norman. Allowing choices on a per acre and per area basis in forest planning. 1981. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Fort Collins, CO. 45 p.

Dana, Samuel T. Forest and range policy - its development in the United States. New York: McGraw-Hill; 1956. 455 p.

Dana, Samuel T.; Fairfax, Sally K. Forest and range policy. 2d ed. New York: McGraw-Hill; 1980. 458 p.

Dantzig, George B. Linear programming and extensions. Princeton, NJ: Princeton University Press; 1963. 627 p.

Davis, Kenneth. Forest management: regulation and valuation. 2d ed. New York: McGraw-Hill; 1966. 519 p.

Doig, Ivan. When the Doug-firs were counted. Journal of Forest History. 20(1): 20-27; 1976.

Dorfman, Robert. Mathematical, or "linear," programming: a non-mathematical exposition. In: Mansfield, Edwin, ed. Managerial economics and operations research: techniques, applications, cases. 4th ed. New York: Norton and Co.; 1953: 319-353.

Duerr, William A. Fundamentals of forestry economics. New York: McGraw-Hill; 1960. 579 p.

Duerr, William A.; Teeguarden, Dennis E.; Guttenberg, Sam; Christiansen, Neils, eds. Forest resource management. Philadelphia, PA: W. B. Saunders Co.; 1979. 612 p.

Dykstra, Dennis P. Mathematical programming for natural resources management. New York: McGraw-Hill; 1984. 318 p.

Field, D. B. Goal programming for forest management. Forest Science. 19(2): 125-135; 1973.

Field, Richard C. National Forest planning is promoting US Forest Service acceptance of operations research. Interfaces. 14(5): 67-76; 1984.

Fight, Roger D.; Johnson, K. Norman; Connaughton, Kent P.; Sassaman, Robert. Roadless area-intensive management tradeoffs on western National Forests. Revised. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978. 57 p.

Fight, Roger D.; Johnson, K. Norman; Connaughton, Kent P.; Sassaman, Robert W. Can intensive management make up the harvest lost when roadless areas are left undeveloped? Journal of Forestry. 77(3): 148-151; 1979.

Gaffney, Mason. Concepts of financial maturity of timber and other assets. A.E. Information Series No. 62. Raleigh, NC: North Carolina State College, Department of Agricultural Economics; 1960. 105 p.

Geoffrion, Arthur M. The purpose of mathematical programming is insight, not numbers. Interfaces. 7(1): 81-92; 1976.

Gilbert, Bradley; Johnson, K. Norman; Crim, Sarah; Marose, Robin; Armel, Bryan. FORPLAN Version 2 user's guide [computer printout]. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1985. Various pages.

Gross, L. A. Timber management plans on the National Forests. Washington, DC: U.S. Department of Agriculture, Forest Service, Division of Timber Management; 1950. 59 p.

Hill, M.; Kirsh, E.; Kirby, M.; Schwarzbart, G.; Valfer, E.; Wagner, D. Analysis of computer support systems for multifunctional planning: Report I. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Management Sciences Staff; 1974. 119 p.

Hrubes, Robert J.; Navon, Daniel I. Application of linear programming to downward sloping demand problems in timber production. Research Note PSW-315. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1976. 6 p.

Hyde, William F. Timber supply, land allocation, and economic efficiency. Baltimore, MD: Johns Hopkins Press for Resources for the Future, Inc.; 1980. 224 p.

Iverson, David C. The genesis of FORPLAN: an historical sketch of U.S. Forest Service resource management decision analysis. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1982. 27 p.

Johnson, K. Norman. A comment on "techniques for prescribing optimal timber harvest and investment under different objectives - discussion and synthesis." Forest Science. 23(4): 444-446; 1977.

Johnson, K. Norman. Timber activity on the National Forests: the second revolution; 1980. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Fort Collins, CO. 8 p. [Mimeo].

Johnson, K. Norman. Assessing the environmental feasibility of proposed timber schedules for the National Forests; recent developments and future needs. 1982. Unpublished paper prepared for Forest Planning Symposium sponsored by the University of California, Berkeley, on file at: U.S. Department of Agriculture, Forestry Service, Fort Collins, CO. 13 p.

Johnson, K. Norman. Personal communication, 1985.

Johnson, K. Norman. FORPLAN Version 1: an overview. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1986. 85 p.

Johnson, K. Norman; Crim, Sarah A. FORPLAN Version 1; structures and options guide. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1986. 214 p., var. numbered plus 8 appendixes.

Johnson, K. Norman; Jones, Daniel B. A user's guide to multiple use sustained yield resource scheduling calculation (MUSYC). Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Timber Management; 1979. 242 p.

Johnson, K. Norman; Scheurman, H. Lynn. Techniques prescribing optimal timber harvest and investment under different objectives—discussion and synthesis. Forest Science Monograph. 18. Washington, DC: Society of American Foresters; 1977. 31 p.

Johnson, K. Norman; Stuart, Thomas W. FORPLAN Version 2: mathematical programmer's guide. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1986. 156 p. plus appendix.

Johnson, K. Norman; Stuart, Thomas W.; Crim, Sarah A. FORPLAN Version 2 - an overview. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1986. 85 p.

Johnson, K. Norman; Stuart, Thomas W.; Russell, William. DE-FORPLAN—an overview. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1982. 80 p. [Draft].

Johnson, K. Norman; Tedder, Phillip L. Linear programming vs. binary search in periodic harvest level calculation. Forest Science. 29: 569-581; 1983.

Kaufman, H. The forest ranger: a study in administrative behavior. Baltimore, MD: Johns Hopkins Press; 1960. 259 p.

Kelly, James W.; Kent, Brian M.; Johnson, K. Norman; Jones, Daniel B. FORPLAN Version 1: user's guide. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1986. 171 p., var. numbered plus 10 appendixes.

Kent, Brian M. The Forest Service land management planner's introduction to linear programming. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1980. 63 p.

Kent, Brian M.; Kelly, James E.; King, John J. FORPLAN Version 1: mathematical programmers guide. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section; 1985. 327 p., var. numbered plus 8 appendixes.

Kirby, Malcolm W. Large-scale budget applications of mathematical programming in the Forest Service. In:

Navon, Dan, compiler. Operational forest management planning methods: proceedings, meeting of steering systems project group, International Union of Forestry Research Organizations; 1978 June 18-24; Bucharest, Romania. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station; 1978: 60-67.

Kirby, Malcolm W.; Wegner, Dwain C.; Visser, Louis. ADVENT: a model for program budgeting, user's guide. 4th ed. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1978. Various pages [looseleaf].

Kirby, Malcolm W.; Wong, Peter; Hager, William A.; Huddleston, Mary E. Guide to the integrated resources planning model. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Management Sciences Staff; 1980. 212 p.

Klemperer, David W. The parable of the allowable pump effect. Journal of Forestry. 73(10): 640-641; 1975.

Koopmans, T. C., ed. Activity analysis of production and allocation: Proceedings of a conference. [Cowles Commission for Research in Economics Monograph No. 13.] New York: Wiley; 1951. 404 p.

Marsh, R. E.; Gibbons, W. H. Forest-resource conservation. In: Farmers in a changing world: the yearbook of agriculture. Washington, DC: U.S. Department of Agriculture; 1940: 458-488.

McArdle, Richard E. An interview [by Elwood Maunder] with the former Chief, U.S. Forest Service, 1952-1962. Santa Cruz, CA: Forest History Society; 1973. 262 p.

McCloskey, J. Michael. Note and comment: natural resources - National Forests - the Multiple Use-Sustained Yield Act of 1960. Oregon Law Review. 41: 49-77; 1961.

McConnen, R. J.; Amidon, E. L.; Navon, D. I. The use of operations research techniques in determining allowable cut. In: Annual meeting, Society of American Foresters: Proceedings; 1967: 109-115.

Navon, Daniel I. Computer-oriented systems for wildland management. Journal of Forestry. 65(7): 473-479; 1967.

Navon, Daniel I. Timber RAM. . .a long-range planning method for commercial timber lands under multiple-use management. Research Paper PSW-70. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1971. 22 p.

Navon, Daniel I.; Lundeen, Dean. A proposal for combined use of RAM and RCS as analytical tools for land use planning: Report I. In: Hill, M.; Hirsh, E.; Kirby, M.; Schwarzbart, G.; Valfer, E.; Wagner, D. Analysis of computer support systems for multifunctional planning. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Management Sciences Staff; 1974: 116-119.

Navon, Daniel I.; McConnen, Richard J. Evaluating forest management policies by parametric linear programming. Research Paper PSW-42. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1967. 13 p.

Neff, Paul E. Calculation of allowable harvest for the National Forests. Journal of Forestry. 71(2): 86-89; 1973.

Oregon State Forestry Department. 1980 Oregon timber supply assessment: projections of future available harvests. Salem, OR; 1980. 165 p.

O'Toole, Randall. The citizens' guide to FORPLAN. Eugene, OR: Cascade Holistic Economic Consultants; 1983. 51 p.

Pack, Arthur Newton. Forestry: an economic challenge. New York: Macmillan; 1933. 161 p.

Pemberton, Billy G. 1976 inter-university symposium on renewable resource assessment and programming: executive summary. General Technical Report PSW-21. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1977. 21 p.

Pickens, James B. NIMRAS system documentation. [Prepared for Peter G. Ashton, 1980 June 30.] Washington, DC: U.S Department of Agriculture, Forest Service; 1980. 45 p. plus 2 appendixes [mimeo].

Robinson, Glen O. The Forest Service: a study in public land management. Baltimore, MD: Johns Hopkins University Press for Resources for the Future; 1975. 337 p.

Sassaman, Robert W.; Holt, Ed.; Bergsvik, Karl. User's manual for a computer program for simulating intensively managed allowable cut. General Technical Report PNW-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1972. 50 p.

Samuelson, Paul. Economics of forestry in an evolving society. Economic Inquiry. 14: 466-491; 1976.

Schweitzer, Dennis L. Analysis to support planning for the National Forests in the United States. In: Kaiser, Fred; Schweitzer, Dennis; Brown, Perry, compilers. Proceedings for economic value analysis of multiple use forestry, International Union of Forest Research Organizations meeting; 1984; Denmark. Corvallis, OR: Oregon State University, Department of Resource Recreation Management; 1984: 123-132.

Schweitzer, Dennis L.; Cortner, Hanna J. Evolution of planning requirements for national public forestry in the United States. In: Kaiser, Fred; Schweitzer, Dennis; Brown, Perry, compilers. Proceedings for economic value analysis of multiple use forestry, International Union of Forestry Research Organizations meeting; 1984; Denmark. Corvallis, OR: Oregon State University, Department of Resource Recreation Management; 1984: 112-122.

Schweitzer, Dennis L.; Sassaman, Robert W.; Schallau, Con H. Allowable cut effect: some physical and economic implications. Journal of Forestry. 70(7): 415-418; 1972.

Shands, William E.; Healy, Robert G. The lands nobody wanted: policy for National Forests in the eastern United States. Washington, DC: Conservation Foundation; 1977. 282 p.

Steen, Harold K. The U.S. Forest Service: a history. 2d printing, with corrections. Seattle: University of Washington Press; 1977. 356 p.

Stuart, Thomas W.; Kent, Brian. Forest planning models in the USDA Forest Service: Where are we now? How did we get there? Where might we go from here? Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning; 1982. 24 p. [Draft unpublished paper.]

Teeguarden, Dennis E. The allowable cut effect: a comment. Journal of Forestry. 71(6): 357-369; 1973.

Thompson, Emmett F.; Halterman, Bernard G.; Lyon, Tunis J.; Miller, Robert L. Integrating timber and wildlife management planning. The Forestry Chronicle. 49(6): 247-250; 1973.

Towle, Everett L. A brief history of forest policy and the Forest Service in the United States. In: Actes du symposium international d'histoire forestiere, Vol. II, pp. 284-304. 1982. [Nancy, France: Ecole National du genie rural des eaux et des forets.]

Twight, Ben W. Organizational values and political power: the Forest Service versus the Olympic National Park. University Park, PA: The Pennsylvania State University Press; 1983. 139 p.

U.S. Congress, Senate. A national plan for American forestry. Senate Document No. 12, 73d Congress, First Session, 2 vols.; 1933. 1677 p.

U.S. Department of Agriculture, Forest Service. The use of the National Forests. Washington, DC; 1907. 42 p.

U.S. Department of Agriculture, Forest Service. The National Forest manual. Washington, DC; 1911. 45 p.

U.S. Department of Agriculture, Forest Service. Forests and national prosperity. Miscellaneous Publication 668. Washington, DC; 1948. 99 p.

U.S. Department of Agriculture, Forest Service. Forest land resources, requirements, problems, and policy. Part 8 of the supplementary report of the Land Planning Committee to the National Resources Board. Washington, DC; 1935. 114 p.

U.S. Department of Agriculture, Forest Service. Price trends and relationships for forest products. Washington, DC; 1957. 58 p.

U.S. Department of Agriculture, Forest Service. Timber resources for America's future. Forest Resource Report 14. Washington, DC; 1958. 713 p.

U.S. Department of Agriculture, Forest Service. Timber trends in western Oregon and western Washington. Research Paper PNW-5. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Division of Forest Economics and Research; 1963. 154 p.

U.S. Department of Agriculture, Forest Service. Douglas-fir supply study: alternative programs for increasing timber supplies from National Forest lands. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1969. 53 p.

U.S. Department of Agriculture, Forest Service. Management practices on the Bitterroot National Forest. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region; 1970. 100 p.

U.S. Department of Agriculture, Forest Service. Forest management in Wyoming - timber harvest and the environment on the Teton, Bridger, Shoshone, and Bighorn National Forests. Ogden, UT: Intermountain Region; and Denver, CO: Rocky Mountain Region; 1971. 80 p.

U.S. Department of Agriculture, Forest Service. Emergency Directive No. 16 [to FSM 2410.3]. Washington, DC; [issued May 1] 1973. 2 p.

U.S. Department of Agriculture, Forest Service. Socioeconomic overview for unified planning, Beaverhead National Forest. Publication No. R1-74-005. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region; 1974. 96 p.

U.S. Department of Agriculture, Forest Service. Timber harvest scheduling issues study. Washington, DC; 1976. 292 p. plus 105 p.

U.S. Department of Agriculture, Forest Service. The nation's renewable resources—an assessment, 1975. Forest Resource Report 21. Washington, DC; 1977. 243 p.

U.S. Department of Agriculture, Forest Service. Letter from Douglas R. Leisz, Associate Chief, to Regional Foresters and National Forest Systems Staff Directors; File 1920; Subject: Development and use of forest planning model. 1979 December 3.

Walker, John L. An economic model for optimizing the rate of timber harvesting. Seattle: University of Washington; 1971. 117 p. Ph.D. dissertation. [Diss. Abstr. 32(5): 2276-A] [Microfilm No. 71-28489].

Watershed Systems Development Unit. The resource capability system: user's guide. Part I: an overview. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1972. 51 p.

Weintraub, Andres; Navon, Daniel. A forest management planning model integrating silvicultural and transportation activities. Management Science. 22(12): 1299-1309; 1976.

Wikstrom, John H.; Hutchison, S. Blair. Stratification of forest land for timber management planning on the western National Forests. Research Paper INT-108. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1971. 38 p.

Wilkinson, Charles F.; Anderson, H. Michael. Land and resource planning in the National Forests. Oregon Law Review. 64(1 and 2): 1-373; 1985.

APPENDIX I: LINEAR PROGRAMMING IN BRIEF

The essence of linear programming (LP) can be conveyed by means of a relatively simple but concrete example. We present one illustration in a production context. Our purpose is only to introduce the basic concepts of linear programming. The reader who would learn to solve an LP problem, even the simplest, will have to look elsewhere. The standard references include Dantzig (1963) and Koopmans (1951). A nonmathematical, graphical approach may be found in Dorfman (1953). For the person who seriously wants to learn how to apply LP, see Baumol (1977), which includes an extensive treatment of the theory, sample applications in a variety of contexts including production, and simple problems to be worked out by the reader (with answers conveniently provided in the back of the text). For mathematical programming examples specific to natural resources management, see Dykstra (1984). Kent (1980) provides an introduction focusing on forest management. Of course, the short cut is to turn to widely available LP software compatible with personal computers. We do not recommend this approach except to those who have spent at least some time familiarizing themselves with the assumptions and limitations of the approach.

Forests are capable of producing multiple products, or outputs. For simplicity, assume that a 1,000-acre forest can produce varying amounts of timber, water, range forage, and primitive recreation depending on the number of acres allocated to each use. Forested land occupies 600 acres and rangeland covers the remaining 400 acres. For simplicity we assume two management strategies represented by decision variables for each type. Forested acres may be managed emphasizing either (1) timber or (2) primitive recreation, but not both. Rangeland, it is assumed, may be managed emphasizing (1) grazing and primitive recreation or (2) no grazing and primitive recreation. For this example we assume that timber management precludes primitive recreation and lowers water quality, and that grazing lowers quality, therefore value, of both water and recreation. Inputs will be limited to (1) the acres assigned to each use category and (2) the management activities (expenditures) undertaken for each output. We'll assume that the output per acre per year for timber is 15 M bd ft, for water is 0.1 acre-foot, for range is 0.5 animal unit months (AUM), and for recreation is 2 recreational visitor days (RVD). The management cost of an incremental unit of timber output (M bd ft) will be constant across all forested acres and equals, say, $10 per unit of output. Costs associated with a unit of water are $1.20 per acre-foot, range forage costs are $7 per AUM, and recreation costs are $4 per RVD. Stumpage values are $15 per unit, water $3 or $5 per unit (depending on quality), range forage $9 per unit, and recreation $5 or $7 a unit (depending on quality). Two final assumptions are that acres allocated to any management strategy are not available for other purposes, and the budget available for land management purposes is $8,000.

We may formulate this relatively simple (and simplistic) problem and display the output information and summarized cost and benefit data as shown in the following tabulation. The problem is to determine which use should be chosen in order to maximize the objective function—that is, the total (gross) value attainable in this example.

	Timber	Water	Range	Primitive recreation	Available
	Input required to produce one unit of output per year[1]				
Acres	0.067				600
		10		0.5	1,000
			2		400
$ management	10	1.2	7	4	8,000
	Dollar value per unit				
Forested land	15	3	—	—	Timber emphasis
	—	5	—	7	Primitive recreation emphasis
Rangeland	—	3	9	5	Grazing emphasis
	—	5	—	7	No grazing/ recreation emphasis

[1]Outputs per acre have been transformed into the acres required to produce one unit of output (for example, 15 M bd ft per acre for timber implies it requires 1/15 = 0.067 acre to produce 1 M bd ft).

To find the answers we may translate the problem into the following linear program in the four continuous decision variables (Timber emphasis = x_1, Primitive recreation emphasis = x_2, Grazing/Recreation emphasis = x_3, No grazing/Recreation emphasis = x_4). In this formulation each decision variable is associated with an activity column specifying the physical production relationships associated with each strategy. Also associated with each decision variable are coefficients that show the benefits (in the objective function) or costs (in the budget constraint) that are relevant to that decision variable. Note, however, that the objective function values are derived by multiplying the dollar value ($) per unit by the output per acre and summing across outputs produced under the management strategy. Thus, in the case of the timber emphasis, for example, the coefficient 225.3 for x_1 is obtained by multiplying the value of $15 per M bd ft times the output per acre of 15 M bd ft and then adding the $3 water value per acre-foot times the output per acre of 0.1 acre-foot: ($15 × 15) + ($3 × 0.1) = 225.3. Other coefficients, including those in the budget constraint, are similarly derived. Note also that water values are lower when timber harvesting is present ($3) in comparison to water values in the absence of timber harvesting ($5), reflecting our assumption of changes in water quality. In a similar fashion, the value of recreation is negatively impacted by the grazing activity, when present ($5 with grazing vs. $7 without). Inspection will show that grazing also negatively affects water quality and value, as was the case with timber harvest.

Mathematically, the model specification is:

Maximize value:

$$V = 225.3x_1 + 14.5x_2 + 14.8x_3 + 14.5x_4$$

Subject to:

acreage constraints

$$1x_1 + 1x_2 \leqslant 600$$
$$1x_3 + 1x_4 \leqslant 400$$

budget constraint

$$150.12x_1 + 8.12x_2 + 11.62x_3 + 8.12x_4 \leqslant 8{,}000$$

To rule out absurd results we must also impose nonnegativity requirements: $x_1 \geqslant 0$, $x_2 \geqslant 0$, $x_3 \geqslant 0$, $x_4 \geqslant 0$.

This is the standard form for an LP problem. It consists of four parts: (1) the function (V) (such as profits, costs, present net value) whose value is to be maximized or minimized, which is called the objective function; (2) the prescriptions or activity columns $\{a\}_j$'s represent the potential strategies for land use and are associated with decision variables (x_j's); (3) the constraint rows, such as capacity, budget, or minimum output, and (4) the nonnegativity conditions on the variables. The above example contains the case of four decision variables and three constraints.

We state the generalized n-variable, m-constraint linear program in two ways: in longhand and in summation (Σ) notation. (A third approach, matrix notation, is not presented here.)

When completely written out, a maximization program in n variables and subject to m constraints will appear as follows:

$$\begin{array}{llcl}
\text{Maximize:} & V = c_1 x_1 + c_2 x_2 + \ldots + c_n x_n & & \\
\text{Subject to:} & a_{11} x_1 + a_{12} x_2 + \ldots + a_{1n} x_n & \leqslant & r_1 \\
& a_{21} x_1 + a_{22} x_2 + \ldots + a_{2n} x_n & \leqslant & r_2 \\
& \cdot \quad \cdot \quad \cdot & & \cdot \\
& \cdot \quad \cdot \quad \cdot & & \cdot \\
& a_{m1} x_1 + a_{m2} x_2 + \ldots + a_{mn} x_n & \leqslant & r_m \\
\text{and} & x_j \geqslant 0 \; (j = 1, 2, \ldots, n) & &
\end{array}$$

The value of the objective function (V) is to be maximized. The decision (choice) variables are denoted by x_j ($j = 1, 2, \ldots, n$). The coefficients in the objective function are designated by c_j (with $j = 1, 2, \ldots, n$) and are a set of given constants. The r_i symbols ($i = 1, 2, \ldots, m$) are another set of constants and represent restrictions (or requirements, in which case the inequality would be reversed, $\geqslant$). Of course, each of the constraints (restrictions or requirements) could be written as strict equalities (=). The coefficients for the decision variables in the constraints represented by a_{ij} ($i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$) are also a set of given constants.

A substantial savings in space can be achieved by expressing the linear programs in summation (Σ) notation:

$$\text{Maximize:} \quad V = \sum_{j=1}^{n} c_j x_j$$

$$\text{Subject to:} \quad \sum_{j=1}^{n} a_{ij} x_j \leqslant r_i \; (i = 1, 2, \ldots, m)$$

$$\text{and} \quad x_j \geqslant 0 \qquad (j = 1, 2, \ldots, n)$$

We use this concise summation notation in appendix II. The notation contains all elements (objective function, constraint set, and nonnegativity requirements) in the standardized version.

Our simple example points up the problems that ultimately faced analysts. Their task was to find a way to formulate the questions faced by decision makers, taking into account the realities of the systems within which forest land management would take place. In our example, acres assigned to timber are assumed unavailable for other uses. In practice, of course, acreage available for timber production may be simultaneously used for domestic livestock forage. Our example only generates a total output level for each decision variable, but it does not tell us where to locate the activities that generate those output levels. This is the spatial problem. Closely related to the spatial question of where to obtain desired outputs is the transportation problem. What about roading costs? When and where will transportation networks need to be developed if the desired levels of output are in fact to be achievable?

Furthermore, our example did not illustrate the fact that certain minimal levels of output for each decision variable may be required if multiple-use mandates (and public demands) are to be met. This is the problem of predetermined minimum (or maximum) levels of output within which the objective function is to be maximized. Such constraints may show up in the form of sustained yield or nondeclining yield requirements, minimum levels of water (quality or quantity), formalized rights to minimum grazing established by permit systems, or acreage that is not available due to administrative assignment (such as research natural areas, wilderness, or visual impact areas).

Our sample problem assumed that there was only one production process or management activity by which to obtain outputs. In the real world, of course, a complex spectrum of options exists. Thus, a particular harvest level in the future may be achieved by increasing acres assigned to harvest, through silvicultural practices such as precommercial thinning and fertilization, or with genetic selection in reforestation practices, to mention only a few options.

Complexities abound. And it was precisely such complexities that led to the model development, refinement, and evolution described in the main body of this paper.

APPENDIX II: MATHEMATICAL STRUCTURE OF VARIOUS FOREST PLANNING MODELS

In this appendix five mathematical structures are presented and related to the various models discussed in the body of the report. The intent is modest and limited to illustrating land use and harvest scheduling in terms of decision variables and rows used to account for acres represented in the problem. A complete description of model structures including discussion of control rows can be found in the mathematical programmer's guides that accompany each of the models (see especially Johnson and Stuart 1986). Given our modest goal, we restrict attention to timber outputs. Extrapolation to other resource products is relatively straightforward. In the following discussion, each relation (objective function or constraint equation) is identified by reference to the model (such as Form A, B, C, D, or E) where it first appears and is defined. Certain relations appear in more than one structure and are numbered to help readers identify those that are repeated and those that are new or unique to a particular model form. For example, the number "B 3" refers to a relation that first appears in Model Form B, and is the third new relation added in the appendix by Model Form B.

FORM A: Timber Harvest Scheduling Model I

The following structure is indicative of timber scheduling problems formulated in Timber RAM, MUSYC, and FORPLAN Version 1 or Version 2. In Model I, a prescription describes the sequence of activities on a user-defined analysis area for each period to the planning horizon.

Maximize: $\sum_{s=1}^{F} \sum_{i=1}^{P_s} \sum_{k=1}^{T_i} A_{sik}\, x_{sik}$ (A 1)

Subject to: area constraints

$\sum_{i=1}^{P_s} \sum_{k=1}^{T_i} x_{sik} = \text{Area}_s \quad s = 1 \ldots F$ (A 2)

and nonnegativity requirements

$x_{sik} \geqslant 0$ for all s, i, k (A 3)

where: x_{sik} = acres assigned to timing choice k of prescription i of analysis area s

A_{sik} = contribution to the objective function per acre from timing choice k of prescription i of analysis area s

F = number of analysis areas

P_s = number of prescriptions for analysis area s

T_i = number of timing choices for prescription i (of analysis area s)

Area_s = size of analysis area s in acres.

FORM B: Timber Harvest Scheduling Model II

The following structure is indicative of timber scheduling problems formulated using MUSYC, FORPLAN Version 1 or Version 2 when Model II is desired (Johnson and Scheurman 1977). In Model II, a prescription describes the sequence of activities on a user-defined analysis area for each period until the area is harvested. Another prescription will then track activities on regenerated acres.

Maximize: $\sum_{s=1}^{F} \sum_{i=1}^{P_s} \sum_{k=1}^{T_i} A_{sik}\, x_{sik} + \sum_{r=1}^{R} \sum_{z=1}^{P_r} \sum_{k=1}^{T_z} B_{rjzk}\, y_{rjzk}$ (B 1)

Subject to: area constraints

$\sum_{i=1}^{P_s} \sum_{k=1}^{T_i} x_{sik} = \text{Area}_s \quad s = 1 \ldots F$ (A 2)

regeneration area constraints

$\sum_{z=1}^{P_r} \sum_{k=1}^{T_z} y_{rjzk} - \sum_{s=1}^{F} \sum_{i=1}^{P_s} \sum_{k=1}^{T_i} x_{sik} = 0$ (B 2)

$j = 1 \ldots J$
$r = 1 \ldots R$

and nonnegativity requirements

$x_{sik} \geqslant$ for all s, i, k (A 3)

$y_{rjzk} \geqslant 0$ for all r, j, z, k (B 3)

where:

x_{sik}, A_{sik}, F, P_s, T_i, and Area_s are defined in Form A

y_{rjzk} = acres established (recognized) in period j that are assigned to timing choice k for prescription z of regeneration class r

B_{rjzk} = contribution to the objective function from an acre established (recognized) in period j that is assigned to timing choice k for prescription z of regeneration class r

J = number of time periods

P_r = number of prescriptions for regeneration class r

R = number of regeneration classes

T_z = number of timing choices for prescription z (of regeneration class r).

FORM C: Timber Harvest Scheduling Generalized Model II

The following structure is indicative of timber scheduling problems formulated with FORPLAN Version 2 (Johnson and Stuart 1986). This structure broadens the Model II structure of Johnson and Scheurman (1977) in three ways: (1) acres can be passed to multiple regeneration classes at regeneration harvest (instead of only one regeneration class), (2) acres can be passed to regeneration classes at all stand ages up to regeneration harvest, and (3) acres passed to a regeneration class can contain stands with an age greater than zero.

Maximize: $\sum_{s=1}^{F} \sum_{i=1}^{P_s} \sum_{k=1}^{T_i} A_{sik}\, x_{sik} + \sum_{r=1}^{R} \sum_{z=1}^{P_r} \sum_{k=1}^{T_z} B_{rjzk}\, y_{rjzk}$ (B 1)

Subject to: area constraints

$\sum_{i=1}^{P_s} \sum_{k=1}^{T_i} x_{sik} = \text{Area}_s \quad s = 1 \ldots F$ (A 2)

regeneration area constraints

$\sum_{z=1}^{P_r} \sum_{k=1}^{T_z} y_{rjzk} - \sum_{s=1}^{F} \sum_{i=1}^{P_s} \sum_{k=1}^{T_i} G_{rjsik}\, x_{sik} -$

$\sum_{r'=1}^{R} \sum_{j'=1}^{j-1} \sum_{z=1}^{P_r} \sum_{k=1}^{T_z} H_{rjr'j'zk}\, y_{r'j'zk} = 0$ (C 1)

$j = 1 \ldots J$
$r = 1 \ldots R$

and nonnegativity requirements

$x_{sik} \geqslant 0$ for all s, i, k (A 3)

$y_{rjzk} \geqslant 0$ for all r, j, z, k (B 3)

$y_{r'j'zk} \geqslant 0$ for all r', j', z, k (C 2)

where:

x_{sik}, A_{sik}, F, P_s, T_i, and Area_s are defined in Form A

y_{rjzk}, B_{rjzk}, J, P_r, R, and T_z are defined in Form B

$y_{r'j'zk}$ = acres established (recognized) in period j' that are assigned to timing choice k for prescription z of regeneration class r'

G_{rjsik} = a factor that gives the proportion of the acres assigned to timing choice k for prescription i of analysis area s that transfers to regeneration class r in period j

$H_{rjr'j'zk}$ = a factor that gives the proportion of the acres assigned to timing choice k

for prescription z of regeneration class r' established (recognized) in period j' that transfers to regeneration class r in period j.

FORM D: Timber Harvest Scheduling Recognizing Contiguous Land Use Zones

The following structure is indicative of timber harvest scheduling formulated, for convenience purposes, in Model I. Model II scheduling is also possible but is not presented here. Activity Columns labeled "allocation choices" are specified for activities, such as roadbuilding, that do not lend themselves to prescription activity columns specified in Forms A, B, or C. Allocation choices are linked to the previously defined prescriptions. Note that scheduling is depicted to be forestwide. In FORPLAN Version 2, the user may choose to impose control on harvest schedules forestwide or at some other level of aggregation defined by the user, including the option to develop schedules by allocation zone. In FORPLAN Version 1, aggregate emphases formulations always scheduled within each allocation zone (or emphasis area). That is, instead of x_{sik} the aggregate emphases formulation developed x_{tsik}. The aggregate emphases formulation, therefore, constitutes a special case of models taking Form D.

$$\text{Maximize:} \quad \sum_{t=1}^{E} \sum_{m=1}^{CH_t} \sum_{n=1}^{T_m} C_{tmn} w_{tmn} + \sum_{s=1}^{F} \sum_{i=1}^{P_{sp}} \sum_{k=1}^{T_i} A_{sik} x_{sik} \quad \text{(D 1)}$$

Subject to: area constraints[4]

$$\sum_{m=1}^{CH_t} \sum_{n=1}^{T_m} w_{tmn} = 1 \qquad t = 1 \ldots E \quad \text{(D 2)}$$

$$\sum_{t=1}^{E} \sum_{m=1}^{CH_t} \sum_{n=1}^{T_m} \text{Area}_{tmnspj}\, w_{tmn} - \sum_{i=1}^{P_{sp}} \sum_{k=1}^{T_i} x_{sik} + u_{spj} - v_{spj} = 0 \qquad \begin{array}{l} j = 1 \ldots J_{sp} \\ s = 1 \ldots F \\ p = 1 \ldots PG \end{array} \quad \text{(D 3)}$$

and nonnegativity requirements

$w_{tmn} \geqslant 0$ for all t, m, n (D 4)

$x_{sik} \geqslant 0$ for all s, i, k (A 3)

$u_{spj} \geqslant 0$ for all s, p, j (D 5)

$v_{spj} \geqslant 0$ for all s, p, j (D 6)

where:

x_{sik}, A_{sik}, F, and T_i are defined in Form A

C_{tmn} = contribution to the objective function per area from timing choice n of allocation choice m on allocation zone t

w_{tmn} = proportion of allocation zone t assigned to timing choice n of allocation choice m

CH_t = number of allocation choices (for allocation zone t)

E = number of allocation zones

T_m = number of timing choices for allocation choice m (of allocation zone t)

$Area_{tmnspj}$ = acres of analysis area s located in allocation zone t (and managed under timing choice n of allocation choice m) which are made available for use by prescription group p in period j

P_{sp} = number of prescriptions from analysis area s that are in prescription group p

T_i' = limited number of timing choices for prescription i. Model reflects a full range of choices, but only a limited number are explicitly represented when used with acreage transfer variables u_{spj} and v_{spj}

u_{spj} = acres from analysis area s made available in periods prior to period j for use by prescription group p that were not used, therefore are available for use in period j by prescription group p

v_{spj} = acres from analysis area s made available in period j for use by prescription group p that are not used in period j, therefore are available for use by prescription group p in subsequent periods

J_{sp} = number of periods in which acres from analysis area s are made available for use by prescription group p

PG = number of prescription groups.

[4]The "proportional approach" outlined by Johnson and Stuart (1986, Chapter 5) specifies area constraints as depicted here and in Form E. Earlier specifications of area constraints (Forms A, B, C) follow what is referred to as the "acreage approach." FORPLAN Version 2 allows for specification of area constraints either way as a user option.

FORM E: Timber Harvest Scheduling Packaged Within Land Use Zones

The following structure is indicative of timber scheduling problems formulated in FORPLAN Version 2 where all activities, outputs, costs, and benefits are uniquely specified by land use zone. With minor modifications, this formulation is also available in ADVENT and IRPM. (In IRPM, "traffic flow" variables are structured as continuous decision variables that are mathematically linked to packaged "project" decision variables. IRPM, therefore, can be viewed as a modified Form E model.) In this formulation, schedules are packaged and embedded into allocation choices. That is, no separate scheduling prescriptions are developed.

$$\text{Maximize:} \quad \sum_{t=1}^{E} \sum_{m=1}^{CH_t} \sum_{n=1}^{T_m} D_{tmn} z_{tmn} \quad \text{(E 1)}$$

Subject to: area constraints

$$\sum_{m=1}^{CH_t} \sum_{n=1}^{T_m} z_{tmn} = 1 \qquad t = 1 \ldots E \quad \text{(E 2)}$$

and nonnegativity requirement

$z_{tmn} \geqslant 0$ for all t, m, n (E 3)

where:

CH_t, E, and T_m are defined in Form D

D_{tmn} = the contribution to the objective function of a particular strategy, mn, practiced on zone t

z_{tmn} = proportion of zone t managed under strategy m with timing choice n.

Summary

Whereas most models are somewhat restricted regarding the type problem to be analyzed, FORPLAN Version 2 can be used to analyze problems using any of the forms discussed. Further, the user may mix and match forms within any problem definition. All other models discussed are largely form dependent. That is, without a great deal of alteration and adjustment, the mathematical form underlying analysis performed with the models is itself dictated by the model. Timber RAM typically analyzed problems represented by Form A. MUSYC analyzed problems represented by either Form A or Form B. FORPLAN Version 1 analyzed problems represented by Form A, B, or D. ADVENT uses Form E. IRPM includes roading and timber project activity columns characteristic of Form E. In addition, "traffic flow" decision variables not characteristic of Form E are specified and linked mathematically to the decision variables associated with projects.

APPENDIX III: GLOSSARY

Many terms familiar to land management planners, resource specialists, and mathematical programmers are given particular meaning in this monograph. Some of the terms have been defined for official Forest Service use. See the Forest Service Manual (FSM 1970.5) and 36 CFR 219.3.

Activity. Any action or treatment defined as an input in a prescription.

Activity column. Aspects of a production relationship specified as a column vector in a linear programming (LP) problem.

Activity schedule. The sequence of activities prescribed in the production of the output(s) under consideration. The activities span many periods from the present to the planning horizon.

Aggregate emphasis. A prescription specifying part of a production relationship for an identified zone of land. The aggregate emphasis packages those aspects of production unique to the zone defined on a "per area" basis. It is represented as an "activity column" with an accompanying decision variable in LP problems. An aggregate emphasis is always used in conjunction with other prescriptions defined for strata-based analysis areas within the zone. It is unique to FORPLAN Version 1.

Allocation choice. A prescription unique to FORPLAN Version 2. It is similar to an aggregate emphasis in Version 1, but allows somewhat more generally defined output scheduling. Specifically, it is used in conjunction with other prescriptions defined for strata-based analysis areas either within the zone or defined such that a portion of the analysis areas is located within the zone and portions located elsewhere on the forest. In the first case an allocation choice is equivalent to an aggregate emphasis. In the second case, output scheduling decisions are modeled forestwide or at a level of aggregation higher than the associated allocation zone.

Allocation zone. A contiguous area of land identified for purposes of analysis. It may be denoted by ecological characteristics such as watershed, by economic characteristics such as haul zone, or by other characteristics suited to the purpose of the analysis.

Analysis area. Area of focus in defining response to prescriptions. Analysis areas represent either contiguous or noncontiguous areas of land. Contiguous analysis areas represent logical management units such as "wilderness areas" or "transportation access areas." Because prescriptions for these areas represent treatment for all lands within the zone, contiguous analysis areas are often referred to as an "area-based" stratification. Noncontiguous analysis areas generally represent scattered areas of land possessing similar characteristics such as site productivity, cover type, degree of access, or some combination thereof. An analysis area so defined is referred to as "strata-based" because all acres included in the analysis area are assumed to respond similarly to a prescription.

Coordinated schedule. An activity column specifying all the production relationships for a zone of land. The activity column specifies both location and timing for all activities, outputs, costs, and benefits from the present to the planning horizon.

Constraint. Restriction or requirement on the quantity of an input used or output produced. Constraints may be defined as "control rows" or defined as restrictions embedded in "activity columns" in LP problems. Additionally, constraints may be defined as control rows to "link" prescriptions together to specify production relationships in some model formulations.

Decision variables. The choices available in optimizing an objective function, subject to a specified set of constraints. In LP problems discussed here, these variables typically reflect the number of acres assigned to a prescription and an associated timing choice.

Linear programming. A special class of mathematical programming problems that requires all relations among decision variables to be linear. Mathematical programming, in turn, deals with determining the optimal allocations of limited resources to meet stated objectives.

Management emphasis. An aspect of a prescription that characterizes the overall goals and objectives for an analysis area managed under that prescription.

Management intensity. An aspect of a prescription that characterizes an investment level or other indicator of the degree to which treatments are prescribed.

Objective function. A mathematical relation stating the set of goals to be optimized when solving a mathematical programming problem. Common objective functions discussed here include "maximize first period timber harvest" and "maximize present net value."

Output. A product, service, or use that results from the application of a prescription to an analysis area.

Output schedule. The sequence of output yields predicted in each period to the planning horizon. An output schedule is often derived as a solution to an LP problem. As such, it is tied to the associated activity schedule.

Period. A time interval, usually a decade, defined for purposes of analysis. Analysts typically define between 15 and 30 such periods in evaluating forest management options.

Planning horizon. The last period for which inputs or outputs are to be explicitly represented, especially in defining constraints.

Prescription. A set of management practices or activities with associated standards and guidelines. Each prescription is a point from a production function, projecting activities, outputs, costs, and benefits through time. A prescription may be defined by a single activity column or by several columns that are linked mathematically for analysis. Decision variables are associated with prescriptions and reflect the number of acres assigned to a prescription for a particular timing choice in the solution to an LP problem.

Timber activity schedule. The sequence of activities or silvicultural treatments prescribed for lands suited for timber production.

Timber harvest schedule. The sequence of timber volumes to be cut in each period to the planning horizon. A harvest schedule is often derived as a solution to an LP problem. As such, it is tied to the associated timber activity schedule.

Timing choice. An aspect of a prescription and its associated decision variable indicating the period of implementation for a set of activities

Treatment. Any action or activity related to the production of outputs. Treatments are defined as activities in a prescription and span many periods from the present to the planning horizon.

Iverson, David C.; Alston, Richard M. The genesis of FORPLAN: a historical and analytical review of Forest Service planning models. General Technical Report INT-214. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 31 p.

Historical review of Forest Service resource planning shows a steady movement away from timber harvest scheduling toward interdisciplinary, integrated planning. Three linear programming models—Timber Resource Allocation Method (Timber RAM), Multiple Use-Sustained Yield Calculation Technique (MUSYC), and Forest Planning Model (FORPLAN)—are evaluated in terms of basic structure and role in the evolutionary process.

KEYWORDS: forest management planning, harvest scheduling, linear programming, multiple use, natural resource management, FORPLAN, MUSYC, Timber RAM

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INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

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